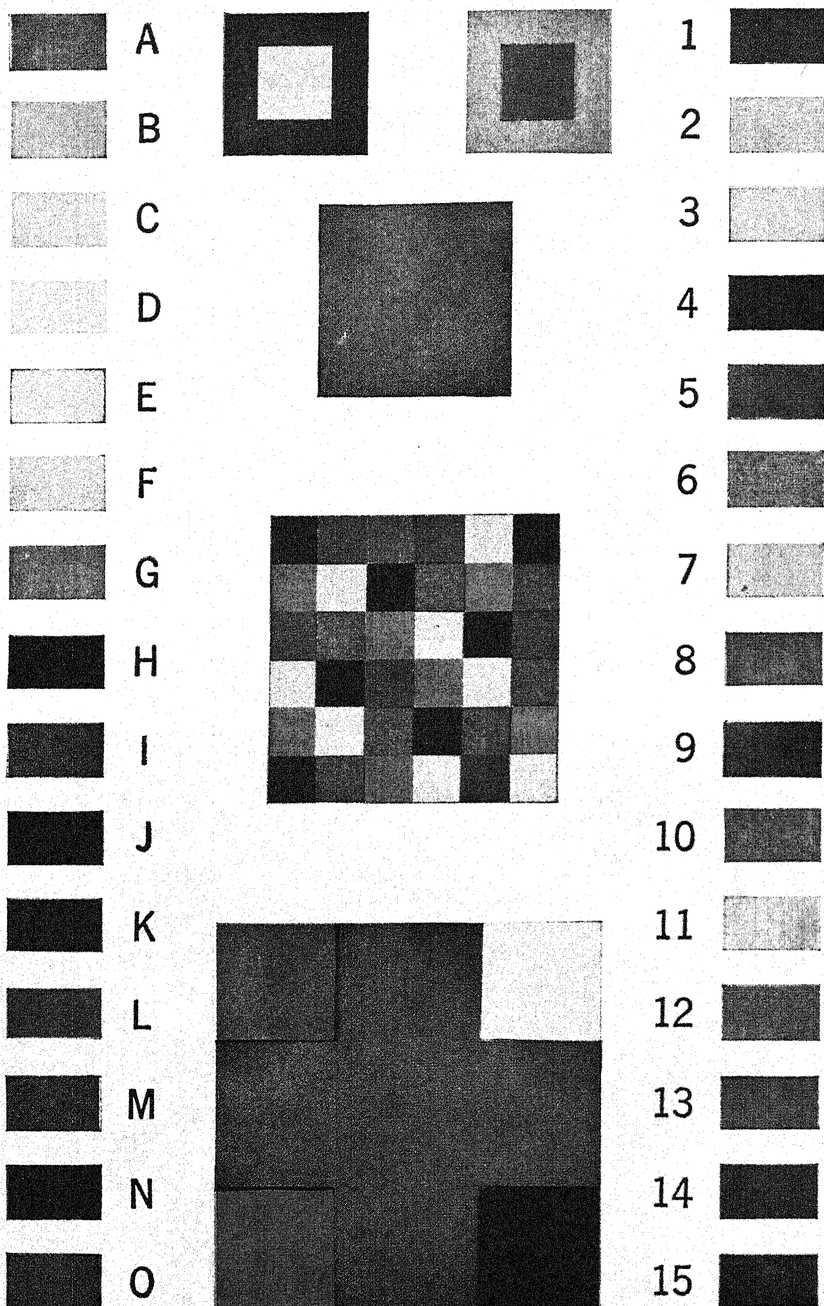

These colors can be used for several purposes. 1. Hue matching: Match each numbered color with one of the lettered colors, considering hue only and not brightness and saturation (p. 478). 2. After-images: Stare for some time at one of the two-colored squares and then at the gray square (p. 484). 3. Color naming: Rapidly name the series of colors in the central square (p. 58). 4. Grouping by similarity: See the yellows in the central square as a group, and the same with each other color (p. 455). 5. Binocular rivalry: Follow directions given with Fig. 93 (p. 487).

Robert S. Woodworth

PSYCHOLOGY

FOURTH EDITION

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Preface to the Fourth Edition

RECENT advances all along the line, as for example in the investigation of ability, intelligence, learning, development and personality, have made a new edition of this book desirable, and helpful criticisms received from teachers and students have encouraged the author to believe he might be able to improve the treatment of many topics. One teacher's comment on the chapter on Thinking was to the effect that it "couldn't possibly be worse." This was distinctly encouraging, and the author was led to scrutinize the several chapters in the hope of seeing how they could be simplified and given more unity and better balance. He has indulged in considerable reorganization, without, however, radically changing the order of the main topics. Some relatively easy subtopics, including the rather large subject of Attention, have been transferred from later chapters to the second chapter where they serve a useful purpose as illustrative material. The subject of Observation has been placed before instead of after the chapters on the senses and serves as an introduction to this phase of psychology. The two chapters on Development and on Heredity and Environment, which involved some overlap and repetition, have been combined into one rather long chapter. The experiments on animal learning, which to many readers have appeared unduly prominent in the chapter on learning, though to the author they seem extremely significant, have been sifted and assembled into a distinct section of that chapter. The treatment of statistical methods, while somewhat amplified, has been relegated to a supplement of the chapter on Individual Differences, so that it can be readily omitted. A determined effort has been made to make the Nervous System more meaningful to the student.

The discussion of Personality has been amplified, and a concluding chapter brings the reader back to the consideration of personal problems. Possible personal applications have been called to the reader's attention in most of the chapters. The book has been entirely renovated so far as concerns the pictorial aids.

It is a pleasure to acknowledge the great assistance given by several colleagues and associates: to Enrica Tunnell who has taken charge of the References and Index, and to Gladys Schwesinger, Mary Sheehan and Milton Smith who have read the manuscript or the proof and offered many useful suggestions. Dr. Smith has prepared a Work Book to accompany the text.

R. S. W.

Columbia University,
March, 1940.

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PSYCHOLOGY

G.c.a

Chapter I

The Aim and Method of Psychology

NO ARGUMENT is needed at the present time to convince us of the value of science. Even if one feels no personal inclination to delve deeply into the natural sciences, one is glad that some people have that inclination. Our complex material civilization would be entirely unworkable without the presence of scientific experts in key positions, as engineers, chemists, physicians and others who make practical use of scientific methods and results and who daily demonstrate the truth of the old saying, "Knowledge is power." Besides its numerous applications, science has a more direct value for anyone who does care to delve into the wonders of nature. Just as travel broadens our outlook and gives our own little town a setting in the wide world, so the sciences conduct us on tours of exploration. They free us from many needless fears and superstitions that oppressed our ancestors and give us a knowledge of the world and a sense of being at home in the world.

When we say "a knowledge of the world," however, we think of the world of human life and affairs. There should be a scientific knowledge of that world. Man himself is well worthy of scientific study. Certainly there is much that is strange and even marvelous in his development and behavior. To understand him would be a great intellectual satisfaction. A science of human behavior must prove in the long run to be immensely practical, too, and even indispensable, if only to balance our increasing mastery of the physical world. "Knowledge is power"—but do we know how to use our power? The World War and its aftermath of economic

confusion and political vagaries put the question squarely before us whether we know enough of man to make good use of our knowledge of physics and chemistry. The causes of war and of poverty, insanity and discontent lie in man and his ways. A science of human behavior—now in the making, though lagging behind the progress of the physical and biological sciences—will furnish the basis for good management of human affairs.

A minor but quite important example is seen in the automobile, an application of physical science which makes of man a different animal so far as speed is concerned. It is really remarkable how skillfully men and women use this new power, but in the aggregate an immense number of accidents occur, and they are due to the human factor more often than to imperfections in the machine or the road.

We need a scientific basis for deciding large political and economic questions and, no less, for managing our private lives. Human happiness depends as much on personal matters as on material conveniences and social arrangements. How to make good use of our abilities, how to improve our personalities, how to get along with our friends, how to adapt ourselves to our environment and how to master the environment—problems like these are difficult to solve by our own unaided efforts. We have a right to look to science for assistance in meeting the problems of life.

The science of human behavior is actually a group of sciences. On one side we find physiology investigating the organs and cells that do the work of the organism, and on the other side we see the social sciences studying nations and groups of mankind. There is room for a middle science that shall focus its attention on the *individual.* That middle science is psychology. Psychology studies the individual's activities throughout his span of life, from his small beginnings before birth up through infancy, childhood and adolescence to maturity, and still further on through the declining years. During this life history he remains the same individual, and his behavior shows continuity along with many changes. Psychology compares child and adult, the normal

and the abnormal, the human and the animal. It is interested in the differences between one individual and another, and still more interested, if possible, in the general laws of activity holding good even of very different individuals—laws, for example, of learning, thinking and emotion. Psychology can be defined as the *science of the activities of the individual.*

The word "activity" is used here in a very broad sense. It includes not only motor activities like walking and speaking, but also cognitive (knowledge-getting) activities like seeing, hearing, remembering and thinking, and emotional activities like laughing and crying, and feeling happy or sad. These last may seem passive, yet they are activities, for they depend on the life of the organism. Any manifestation of life can be called an activity. No matter how passive an individual may seem to himself to be in watching a game or listening to music, he is really carrying on an activity. The only way to be completely inactive is to be dead.

Human activity as viewed by different sciences. Largely, though not exclusively, psychology is concerned with what we ordinarily call "mental" activities such as learning, remembering, thinking, planning, observing, wishing, loving and hating. They are sometimes grouped under the main heads of knowing, feeling and doing. But any mental activity is at the same time a bodily activity. The brain is active in any such performance, and usually the muscles and the sense organs play a part. To discover how the various organs operate is the province of physiology. Physiology picks the organism to pieces, literally or figuratively, and tries to see what each organ contributes to the life of the whole. It asks what goes on in the eye during seeing and in the speech organs during talking. It asks how the muscles work the fingers in grasping an object; and how that enormously complicated organ, the brain, integrates the activities of the individual and enables him to deal effectively with the environment.

If, then, we wish to understand human behavior, does not physiology furnish all we want, so far as any knowledge is available? If the individual's activity can be analyzed into the

activities of his organs, why should we study the individual as a whole? The answer is that physiology furnishes only part of what we need to know. The individual is a real unit. It is the individual that loves and hates, succeeds or fails. He has tasks to perform, problems to solve. He deals more or less effectively and happily with other persons and with things. There is a vast network of interaction between the individual, taken as a whole, and the world about him, and this interaction calls for scientific investigation.

The human individual, much of the time, is interacting with other individuals and taking part in group activity. The group can be taken as a unit and its activities described, as is done by sociology; or the individual can be taken as a unit and his behavior described in its relations with the other individuals; or, again, the activity of the individual can be analyzed physiologically. A football game makes a good example. It could be reported as a struggle between two teams without any mention of the individual players. Team A, having the ball, first tries a certain mass formation which advances the ball a yard, and next tries a certain open play which loses ground. Team A then forms for a kick, but Team B breaks through and captures the ball. And so on. The game could also be described as consisting of the actions of the individual players; to be complete, the description would have to tell what each player heard, saw and felt, what he attempted to do, what obstacles he encountered and how he came out of each play. It would make a very involved story. Theoretically the same game could be described in physiological terms, for certainly the muscles, lungs, heart and brain of every player are active throughout the game. The physiological description, if at all complete, would fill the Sunday newspaper and contain much valuable information, but would be disappointing to any reader who wanted to follow the game.

So we can have physiological, psychological and sociological pictures of human activity, each picture true and valuable. They are like maps of the same country drawn to different scales. One map shows much more detail, another

gives a better idea of the general shape of the country. Human life can be charted in its broad social relations or in its internal organic details. Psychology, however, uses a medium scale such as brings out the activities and relations of the individual.

SCIENTIFIC METHOD IN PSYCHOLOGY

During its long history down to the middle of the nineteenth century, psychology was cultivated by able thinkers who did not realize their need of carefully observed facts. They relied on general impressions derived from past experience. They felt, as many persons do today, that having observed people all their lives they certainly knew psychology pretty well, or at least were in possession of all the necessary facts and needed only to give careful thought to any question that might arise. When they came to discuss psychology with each other, however, they were often in disagreement and saw no way of settling the disputed questions. Finally it became clear that psychology, like other sciences, must explore and observe in order to make any substantial progress.

There was an anecdotal period when the need for concrete facts was recognized but no systematic investigations were undertaken. Anecdotes in some cases are true reports of actual behavior, but in other cases the facts were not well observed in the first place and have since been partly forgotten or even distorted in memory. Scientists find it necessary to sharpen their powers of observation by the use of instruments and by setting up definite questions of fact to be answered by observation; and they find it necessary also to record their observations on the spot and not trust to memory.

Anecdotes and general impressions derived from past experience are likely to give a one-sided view of the facts on any controversial question. Someone tells you he knows from his own experience that bad luck comes on the 13th of the month, for he has taken pains to notice and feels sure of his facts. But has he duly taken note of the *negative instances*,

when good luck came on the 13th or bad luck on some other day, or did only the positive instances make any deep impression? If anyone thought it worth while to make a scientific study of the matter, he would keep a diary and note down each day his good and bad luck—taking care to use the same standards of good and bad luck throughout the investigation—and finally sum up the results over a long period of time. In this way the memory error, the error of one-sided selection of cases, and the error of too few cases would all be avoided.

The experimental method. Finally psychologists decided they must follow the lead of physics, chemistry and physiology and transform psychology into an experimental science. Whenever a process or activity is to be studied, experiment is the ideal means of getting the facts.

An experiment is sometimes described as a "question put to nature." A successful experiment is one that gets a clear answer from nature. The experimenter approaches nature with a question, and his skill lies in so putting the question as to obtain an answer. What is implied by the word "nature"? We speak of the "uniformity of nature," meaning that under the same conditions the same thing will happen, the same result be obtained. A psychological experiment carries the implication that human behavior belongs in the system of nature, so that, given the same conditions, the same behavior will occur.

To put a question to nature is to arrange the conditions in a certain known way and then observe what happens. Sometimes, in a preliminary survey, the question asked is very general and amounts simply to this: Under these known conditions, what happens? Often apparatus is used either to produce the desired conditions or to assist in observation.

Let us take an example. Knowing that an aviator or balloonist trying for an altitude record is likely to lose his good sense and finally to lose consciousness at extreme heights, an experimenter makes a preliminary survey of what happens under these conditions. He might make an ascent with an aviator, and devote himself to obtaining records of breathing,

heart rate, blood pressure, sight, hearing, muscular strength, and performance in psychological tests at different altitudes. (A difficulty with this simple plan of experiment is that the experimenter himself is probably not immune to the effects of altitude, so that he would lose his efficiency as an observer; but there are ways around this difficulty as we shall see.)

The preliminary survey may raise specific questions on which it is important to be perfectly sure of the facts. For example, at what altitude do the first symptoms appear? A new experiment is conducted with attention and equipment concentrated on this one point. It is found that breathing is noticeably hastened at about 12,000 feet and that muscular weakness and headache begin to appear at about 14,000. Many specific questions must be answered before the whole story is known, and some important questions may be very difficult to answer. What form of psychological test, for example, can be used to show that the pilot is beginning to lose his good judgment, so that he may be warned in time? Such a question is likely to require many experiments before it is settled.

Analyzing the conditions. Much more penetrating questions than those so far suggested are tackled by the method of experiment. We said that when all the conditions are the same the result will be the same. But some conditions may be unimportant. The day of the month, whether the 13th or some other, is a condition that certainly makes no difference. Given the same weather conditions, the same condition of the plane and the same handling of the plane, it will fly the same on any day of the month. But in many cases we cannot judge in advance of a trial whether a certain condition will or will not make any difference.

Going up in the air changes several conditions at once, and we wish to dissect this complex and find which conditions count in producing aviation sickness.

1. The mere fact that one is in the air may cause fear and nervousness. We can rule this out as relatively unimportant because mountain sickness, essentially the same thing as aviation sickness, occurs when there is no danger of falling.

2. The motion of the plane can cause something akin to seasickness. But the air is smoother at high altitudes and the plane comparatively steady, and yet the sickness comes on at high altitudes.

3. We might think of the cold of high altitudes, but we know that the same cold at low altitudes has no such effects.

4. The atmospheric pressure decreases as one ascends. At 12,000 feet it is reduced to ⅔, at 18,000 feet to ½, and at 28,000 to about ⅓ of the pressure at sea level. But this condition is found to be unimportant (unless at extremely high altitudes) by experiments in which a man is placed in a steel chamber, the air pumped out to ⅓ or less of normal atmospheric pressure, but the man supplied with pure oxygen to breathe.

5. The last experiment indicates that the amount of available oxygen is the important variable. The oxygen is 21 percent of what air there is at any altitude, but in the rare air of high altitudes the amount of oxygen in a lungful is scanty. It is proportional to the atmospheric pressure, being accordingly ⅔ of the normal amount at 12,000 feet, ½ at 18,000, ⅓ at 28,000. Place a man in a chamber in which the composition of the air can be controlled. Without changing the total atmospheric pressure in the chamber, imitate an ascent so far as oxygen is concerned by gradually replacing the oxygen by nitrogen; and you get the same symptoms as in an actual ascent, height for height. The important condition, the "cause" of altitude sickness, is shown to be the shortage of oxygen.

6. There are other factors of some importance residing in the individual himself. Some individuals succumb at much smaller altitudes than others, or at much smaller reductions of the oxygen in a chamber. The individual's "condition," in the athletic use of the word, makes a difference. If he lives for days or weeks on a mountain at 12,000-18,000 feet, he becomes acclimated, loses his mountain sickness and can work fairly well, though perhaps not so well as in more usual human habitations (up to 6,000 feet) (*1, 2*).[1]

[1] Italicized numbers in parentheses refer to the References at the end of each chapter.

These experiments on the effect of altitude are introduced here simply to illustrate the nature of an experiment. The experimenter observes accurately what happens under certain known conditions. He controls the conditions so that he can know them, and in the more elaborate experiments so that he can vary them systematically. Often he varies the condi-

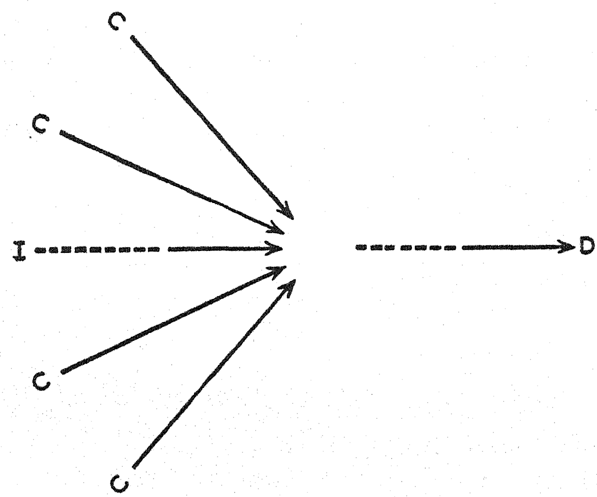

FIG. 1.—Scheme of an experiment. D is the dependent variable, the subject's "response" in a psychological experiment. The converging arrows are the influences or conditions which may affect the response. Those marked C are held constant throughout the experiment, whereas the one marked I, called the independent variable, is made to vary, and the resulting variation in D is observed. What effect does I have upon D?—That is the question to be answered by the experiment.

tions quantitatively and measures the effect. In a typical experiment all the factors are under control that can have any influence on the process in question. All these factors are then held constant, except one chosen as the *independent variable*, and this one is made to vary in a known way and the results are noted. The results are changes in some *dependent variable*. For example, amount of oxygen in the chamber is the independent variable, and breathing rate the dependent variable. Let us test four individuals at low and at high "altitude." The four individuals probably differ in breathing rate, but by testing the *same* individuals at both

altitudes we keep the individual factor from distorting the effect of altitude. All the factors are held constant or kept equal, except one, so that any change in the dependent variable can be pinned to this one factor.

The question which an experiment is designed to answer may be called a *hypothesis*. Usually a hypothesis goes beneath the surface and conceives of some underlying process. For example, we have the fact of altitude sickness and conceive, or guess, it may be due to lack of oxygen. Or we have the fact of forgetting, and formulate a hypothesis explaining this fact. The hypothesis is suggested by our past experience or present knowledge of the matter in question. A good hypothesis has two qualities. (1) It is not "wild," not inconsistent with present knowledge. (2) It is definite, so that it can be put to the test of experiment. It enables us to predict what should happen under certain conditions. We then produce those conditions and observe whether the predicted results occur. If not, the hypothesis is disproved. If the predicted results occur, we cannot say the hypothesis is positively proved, for some other hypothesis, not yet conceived, may later be found to predict the same results. A hypothesis cannot be absolutely proved, but it may be found to possess great *power*, i.e., it may predict truly what will happen under a great variety of conditions. The aim of experimental science is to disprove false hypotheses and to improve those that remain, so as to give them more power and generality.

Psychological experiments. We may designate the experimenter by the letter *E*, and the subject (individual) whose activity is observed by the letter *O*, standing for "organism" or "one observed." The dependent variable is some phase of *O*'s activity. *E* is to discover what *O* does under certain conditions, how he behaves, what his reaction is, how he is affected by the independent variable. If *O* is a human individual, he usually receives certain *instructions* from *E*; he is assigned a certain *task* to perform. He is not usually told the ultimate purpose of the experiment, but he knows what he has to do. The experiment is *E*'s, not *O*'s. *E*'s immediate job is in many cases to discover how successfully *O* performs

his task under the conditions of the experiment. The independent variable is some factor in the conditions under which *O* performs his task.

The conditions to be controlled in a psychological experiment are partly environmental and partly lie in *O* himself. To control the external situation is a matter of laboratory technique; for example, a dark room may be needed and a piece of apparatus for exposing a picture exactly $\frac{1}{10}$ of a second. But how shall *E* control the conditions that lie within *O*? Of course, if *O* is ill on a certain day, he is excused from the experiment. His emotional condition cannot be wholly controlled, since he may be excited or worried about the task he has to perform; but with experience as a laboratory subject his emotional condition becomes stabilized. To a surprisingly great extent *O*'s attitude is controlled by *E*'s instructions. *O* accepts the assigned task and sets himself to do it as well as possible. His effort, obviously an important factor, remains fairly constant at a high level. However, certain difficulties may arise.

1. If the task becomes monotonous, *O* may lose interest and slacken his effort, so giving a false result.

2. If the external conditions become unfavorable, *O* may be stimulated to greater effort. Here we see an important psychological fact, but one which conceals the natural effect of the external condition. If *O* is a candidate for admission to an aviation school and is subjected to tests under low oxygen, his effort often increases with the "altitude" and conceals the effect of shortage of oxygen—up to a certain point.

3. If *O* knows, or thinks he knows, the purpose of the experiment, he may take a partisan attitude. In experiments on the effect of moderate doses of alcohol on mental efficiency, *O* may be convinced in advance that alcohol is a depressant, and this belief may lower his effort in the alcoholic condition. If on the contrary he believes that alcohol is a stimulant, hopes so at any rate, he may put in greater effort when he has received the dose. *E* endeavors to forestall such changes in *O*'s attitude by giving a control dose part of the

time—some drink free from alcohol but indistinguishable in taste—so that *O* does not know whether or not he has received any alcohol. Such experiments, incidentally, give no evidence of any real stimulating effect of alcohol on mental processes.

Because the conditions lying within *O* cannot be wholly controlled, and because different individuals behave differently in the same situation, it is often necessary to plan a psychological experiment on a grand scale, with repeated trials on large groups of subjects, and to use the average results as the basis of any conclusions that are drawn.

The developmental method. One important job of psychology is that of tracing the mental and behavioral development of the individual from birth, or better from before birth, up to maturity. There are many difficult questions here regarding the influences of heredity and environment, the conditions favorable to normal development, and the factors that produce such abnormalities as delinquency and insanity. Tests and laboratory methods can be used for measuring the stage of development reached at different ages and for determining growth curves. But to conduct a decisive experiment on development, one would need to have control over the conditions in which the child is reared, and even to subject certain children to conditions presumed to be unfavorable, so as to make sure whether they are really unfavorable in any important degree. Such experiments might yield extremely valuable information. But the psychologist is not going to take it on himself to subject a child to unfavorable conditions. He will not, for example, stunt the child's physical development by an inadequate diet so as to determine whether mental growth suffers. He will perform such experiments on animals, or he will find undernourished children in the community and try to discover whether the malnutrition has had any demonstrable effect on their mentality. At the best, his results will not be so decisive as those of a complete experiment.

Much can be learned, without such an experiment, by simply observing and recording behavior up through childhood.

We say "simply" observing and recording; but the task is far from simple if dependable results are to be obtained. The child behaves *so much* that an observer cannot record more than small samples. Moreover, the records of a child's behavior, though interesting, may not prove or disprove anything, unless the observer has had definite questions in mind, definite hypotheses to be checked by observation. When we know that some important development is about to occur, as that the child will soon begin to talk, or that he is soon to have a baby brother or sister to whose presence in the family he must adjust himself, we can formulate specific questions to be answered from observations of his behavior. The whole job of tracing child development is large and many-sided, but fortunately it is being seriously undertaken by many scientific observers.

In the true developmental method the observer is on the spot and watches the process as it occurs. But often the psychologist finds that something unforeseen has occurred. He has before him a genius, a criminal, a "problem child," or a remarkably fine personality, and the question is how this individual came to be what he is. The psychologist is forced to adopt a substitute for the true developmental method by reconstructing the individual's developmental history as well as can be done from the memory of the individual and his associates and from whatever records have been preserved. This *case history method* has obvious disadvantages, much like those of the anecdotal method. It depends largely on fallible memory of incidents that were not scientifically observed in the first place. But it seems to be the only way to make a start toward answering some very important questions.

The case history method, up to the present time, has been employed mostly with individuals whose behavior is undesirable in some respect. When a person has broken down mentally, the psychiatrist with the assistance of a social worker obtains information on this person's heredity and family environment, noting such conditions as are believed to be important. The patient's own story is taken down and

the attempt is made to get back to earlier emotional conflicts which may have a bearing on his present trouble. When a child presents a serious behavior problem—such as stealing, overaggressiveness, destructive "meanness," or shyness and dependence—he may be taken to a child guidance clinic, where a staff of experts considers his history from several points of view, medical, psychological and social. These experts approach the child in a friendly spirit, and make him see they are not trying to "get something on him," but wish to help him by first understanding him. They need co-operation from him and from his parents, and their inquiries must be conducted with tact as well as skill. They work on the assumption that the child's misconduct has causes which should be discovered, causes lying in his environment and in his own limitations.

The guidance clinic does more than reconstruct the history of the case to date. In co-operation with the home and the school, it tries an experiment on the child, by way of treatment. Any treatment of such a case is experimental in some degree, since there is no certainty of success. The case history and present state of the child suggest some cause of the misconduct; and the treatment tests this hypothesis by altering certain conditions of the child's life. The hypothesis may be that the child is spoiled or overprotected or denied affection at home, or that his school placement is above or below his mental age, or that his silly behavior, enuresis, fussy eating habits or temper tantrums are just his way of bidding for attention. Treatment in line with any such hypothesis evidently calls for co-operation from parents or teachers. If the treatment succeeds, the hypothesis works and is verified to that extent; if the treatment fails, some other hypothesis must be given a trial.

Case histories of outstandingly fine or successful persons are decidedly lacking so far. The behavior clinics are conducted for the benefit of those who have got into trouble; and the adult, unless he has got into trouble of some sort, is sensitive about being probed. If we could tell in advance that a given newborn baby was going to become great or

fine, we could study his development as it proceeded. A biography, written long afterward, is almost sure to be meager and unpsychological in its account of the subject's early development. Now that many children, including some of great promise, are being studied, we may hope in time to possess some authentic developmental biographies of normal and superior people.

Objective and introspective data. A *datum* (plural, *data*) is an observed fact used in testing a hypothesis or reaching any conclusion. What kinds of data are available in psychology? Shall we ask *O* to observe his own activities, or shall *we* observe them? We can observe his behavior objectively; he can give us inside information of his thoughts, feelings and intentions and of what he sees, hears and knows. When he observes his own activities, he is said to *introspect*, and the data he furnishes are introspective data. They are also called *subjective* data, because they are furnished by the subject from self-observation.

Introspection, as understood in psychology, is not brooding over one's troubles or worrying about one's personality. It is not even attempting to explain one's actions. It is distinctly a form of observation. One kind of introspection is illustrated by observations of the "after-image." If you look fixedly for 20 seconds at a black square and then look at a gray wall, you will see a white square on the wall. The square moves when you move your eyes, and so must be a subjective phenomenon, occurring in you, not on the wall. Everyone, after a little practice, can observe his own after-images but no one can observe those of another person, just as no one can observe another person's toothache. In experiments on the senses, with human subjects, the customary procedure is to apply a suitable stimulus and ask *O* to report what he sees or hears or smells. Introspection in such experiments is the same as any ordinary observation, except that *O* understands that his senses are being tested and does not try to beat the game by utilizing extraneous sources of information. If his eyes are being tested he does not sneak up close to the test chart beforehand so as to know the letters he is

supposed to read from a distance. He simply reports the impression he gets from the given stimulus.

Sometimes the introspection is a little more complex. In an experiment on reading, the letter group

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is shown for a fraction of a second, and *O* reads "psychology" but reports experiencing some strain and dissatisfaction and noticing a messy appearance of the first part of the word. We see from this report that the misspelling made some impression on *O* though not enough to enable him to read the actual sequence of letters. Still more complex is the introspection of the thought process in solving a puzzle. As soon as the solution is reached, *O* reviews the process and reports what he can remember of it. He recalls the steps he went through and so gives a more complete picture of the process than the experimenter can get from observing his behavior.

Some psychologists would exclude introspective data altogether, believing them untrustworthy. Undoubtedly the more complex kinds of introspection make rather heavy demands on the subject. But results show that you can trust introspection if you do not expect it to go into minute detail. Who can doubt, for example, that a well-practiced act goes on almost automatically, or that inner, silent speech is commonly present in the process of thinking? Yet we have only introspection to vouch for these statements. In conversation we accept a person's introspection if he says, "I didn't hear what you said," or "I agree with you," or "That proposition leaves me cold," or "I feel strongly on the matter." We could not dispense with introspection in everyday life and there is no reason for excluding it from psychology. It is true that a person needs some training before he can be trusted to give very accurate introspection. He is apt to explain his actions rather than simply to report what he can observe of his thoughts, feelings and actions.

To say, as used to be said, that psychology is *purely* an

introspective science, making no use of objective data, is absurd in face of the facts. We have animal psychology where the data are wholly objective. The animal performs, the psychologist does the observing. The same is true of child psychology, at least for early childhood. In studying anger in children, we describe their angry behavior and endeavor to determine the conditions which elicit this behavior. Older children and adults are capable of introspection but even here the bulk of experimental work is of the objective type. Nearly all psychological tests are objective. The subject is given a task to perform and the psychologist measures the speed or the accuracy and excellence of the performance. In laboratory experiments, as well as in tests, most of the data obtained are objective; the performer is one person, the observer another.

In studying memory, you assign a lesson to be learned under certain conditions, and note how quickly and perfectly *O* learns the lesson; then you give him another, equally difficult lesson to learn under altered conditions and observe whether he does better or worse than before. Thus you discover which conditions are more favorable for learning and draw some conclusion as to the nature of the learning process. In the whole experiment you may not have called for any introspections—or you may have secured some introspective data in addition to the objective data.

Objective psychological data usually record what *O* did under certain conditions. They record his overt, external behavior. Another type of objective observation seeks to observe what goes on inside the organism during anger, joy, work or any specified kind of behavior. It employs apparatus to record *O*'s breathing, heart beat, stomach movements, flow of saliva, electric currents in the brain, involuntary eye movements, muscular tension in the legs, etc. The purpose is to see how different organs take part in the behavior of the whole organism. We wish to know not only *that* *O* learns, perceives, thinks, loves and hates, but also *how* he does these things. Physiology affords one line of attack on this question, introspection another. But the usual line of

attack is neither physiological nor introspective. It is, rather, an objective study of behavior and performance under different conditions, so chosen as to test some hypothesis. This is the line of attack just suggested for the study of memory, and illustrated earlier by the experiments on aviation.

At one time it was customary to distinguish psychology as sharply as possible from the natural sciences and to say that it dealt with an inner world of experience, altogether separate from the external world. This sharp separation broke down before the fact already stated, that every mental activity is at the same time a bodily activity. It breaks down also before the fact that inner experience is concerned very largely with the external world. Not only when our eyes are open to the scenes of the day, but even in the darkness and quiet of night, our thoughts are concerned mostly with external things. We are reviewing the events of the day or planning what we shall do in the world tomorrow. The ideas and concepts in which we think have been formed in our dealings with the things, persons and happenings of our environment. The field of psychology is therefore not separate from the fields of the natural and social sciences. It is part of the same big field. The individual's behavior belongs squarely in the world of natural phenomena and his conscious experience is bound up closely with his external behavior, both being parts of the same activity.

The terms used in psychology. The terminology of psychology is often a source of unnecessary difficulty. Since we are to be studying activities, our terms should properly be verbs and adverbs. We shall need one noun, *individual* or *organism*, as the subject of all the verbs. When we dip into physiology we need the names of bodily organs, and when we speak of external objects we need their names. But the reader will encounter a host of other nouns, names of activities and ways of acting, such as intelligence, personality, memory, imagination, thought, will, sensation, emotion, attention, perception, consciousness, behavior. Most of these nouns are properly verbs with "individual" understood as their subject.

Instead of "memory" we should properly say "remembering" or "*O* remembers"; instead of "sensation" we should say "seeing," "hearing," etc.; and instead of "emotion" we should say that someone feels eager or angry or afraid. But, like other sciences, psychology finds it convenient to transform its verbs into nouns. Then what happens? We forget that our nouns are merely substitutes for verbs, and start hunting for the *things* denoted by the nouns—for substances, forces, faculties—but no such things exist; there is only the individual engaged in these different activities.

Intelligence, consciousness, the "unconscious" belong with such terms as skill and speed. They are properly adverbs, the facts being that the individual acts intelligently, consciously or unconsciously, skillfully, speedily. A safe rule, on encountering any abstract psychological noun, is to make it concrete by changing it into the corresponding verb or adverb. Much difficulty and unnecessary controversy can thus be avoided.

Summary of the chapter. Psychology undertakes to make a scientific study of the activities of the individual considered as a unit, as he really is in his dealings with other individuals and with the world. As a science, psychology needs data derived from observation. Its data are obtained largely by experimenting and by tracing the individual's development. Some useful data are derived from introspection, in which the individual observes his own activities, but more are obtained by observing the individual's activities objectively. The best data are those obtained in testing some hypothesis regarding the nature of the individual's activities.

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Chapter II

The Individual in His Environment

ONE fundamental principle of any natural science has already been suggested in our study of methods. Psychology is an empirical or factual as contrasted with a deductive science. It must base its conclusions on observed facts. It must test its hypotheses by collecting data. It cannot, like geometry, lay down a few axioms and definitions, combine these in various ways and think out a vast system of sound and logical conclusions. The psychologist uses some mathematics and must do some hard thinking to make sure that his various conclusions are consistent with each other, but he needs, above all, to square his conclusions with observed facts.

Besides this methodological principle, there are some general characteristics of the individual's behavior which can be taken as principles of psychology.

INTERACTION WITH THE ENVIRONMENT

Defined as the science of the activities of the individual organism, psychology might seem to be limited to what goes on inside the individual, inside his skin. Such a study would be physiology rather than psychology. The individual is in active relations with his environment and his dealings with the environment make up what we call his behavior. His conscious experience also, as pointed out in the preceding chapter, is concerned very largely with the environment. Far from studying the individual in isolation, psychology practically takes as its field of study *the activities of the individual in relation to the environment.*

Dependence on the environment. An organism can live only in a suitable *medium* which must be neither too hot nor too cold and in other ways must supply living conditions. Any activity of the organism consumes *energy* derived from the environment in the form of fuel and oxygen. The fuel is taken in as food, stored in the body, and oxidized from time to time in the activities of the organism. Further, the organism depends on the environment for *stimulation* and for what we may call opportunity or *outlet* for activity. It needs something to act upon, as a squirrel needs trees to climb. A talking organism, if it is to engage in this activity, needs something to talk about (stimulation) and somebody to talk to (outlet).

Resistance to the environment. The organism certainly depends on the environment in many ways. What is not so obvious is that, far from yielding passively to the forces of the environment, the organism puts up considerable resistance and maintains a degree of independence. If it did not have some power of resistance it would soon cease to exist. A one-celled animal living in water is constantly exposed to forces which tend to dissolve its substance in the water, and resistance to these forces is a fundamental necessity. In warm-blooded animals, including man, a striking instance of resistance is the constant body temperature maintained in spite of external heat and cold. Elaborate physiological mechanisms insure this constant body temperature. Keeping your balance while walking in a strong gusty wind is another clear example of resistance to the environment. One of the best examples is the resistance of the body to infection.

Participation in environmental processes. The individual's activity is part of the process of nature. He takes part in what is going on in the environment. A bird perched on a swaying branch, or a swimmer in rough water, does more than merely resist the external forces; he chimes in with them by adjusting his movements to the rhythm of the branch or of the waves. Keeping step in marching, keeping time in singing or dancing, are familiar examples of what we mean by participation.

The environment of a human individual is constituted in no small degree of other people. The child is born into a social group on which he is very dependent. The group provides for his needs and seeks to control his actions—

FIG. 2.—Resisting the environment.

meeting with considerable resistance from him, however—and he adopts the language and customs of the group. He depends on the group, he resists the group, and it is very clear that he participates in the activities of the group and that human life consists very largely in such participation.

The individual, then, takes a hand in what is going on in the environment; he deals with the things and persons around him. He perceives them more or less adequately, and manages them more or less effectively. The *scope* of the

human individual's behavior enlarges as he grows from infancy to maturity. It enlarges in both space and time. The baby's "dealings" do not extend far outside his crib, while the adult recognizes the distant mountains and drives toward a destination lying beyond the horizon. The baby's acts are momentary and not tied in with the past and future except to a very limited extent. The farseeing statesman takes account of his country's history in laying plans that may require many years for their execution.

Summing up our discussion so far, we find the individual in active give-and-take relations with the environment. The environment does things to the individual, and the individual does things to the environment. Environmental forces strike the individual; his activity is thus altered and changes the environment, which thereupon causes his activity to change again. This interaction goes on continually.

Keeping the letter *O* to stand for the individual organism, let us use the letter *W* to represent the world or environment. Then the formula,

$$W - O - W,$$

shows the individual acted on by the environment $(W - O)$ and acting on the environment $(O - W)$. Since interaction works both ways, we could just as well transpose the formula and write $O - W - O$. You turn the switch and light the room $(O - W)$; an interesting-looking package on the table immediately catches your eye $(W - O)$; you lift the package $(O - W)$, and it feels heavy $(W - O)$; and so on to the end of the story.

STIMULUS AND RESPONSE

How is it possible for the individual to act upon the environment and for the environment so to act on the individual as to change his behavior? We need some rudimentary knowledge of the process of interaction.

The effectors. We see an individual doing some simple

thing to the environment, such as moving a chair. At first we are contented to say, *he* moves it. Analyzing the process a little, we say he moves it with his *hands*. A little physiology teaches us that the hands are perfectly inert except as moved by their *muscles*. The muscles are inert unless stimulated by their nerves, and these *motor nerves* are inert unless activated by the nerve centers, especially the *brain*. In ordinary life we do not see the individual's brain, nerves and muscles and he himself is unaware of them. He is only aware of the act he is performing, the changes he is producing in the environment.

The muscles are called *effectors* because they produce environmental effects. The only other effectors possessed by the human being are certain glands, such as the salivary glands which moisten food in the mouth. The light organ of the firefly and the electric organ of certain fishes are to be classed as effectors.

The receptors. How does *W* act on *O*? How is the individual made aware of the objects and happenings in the environment? He sees and hears objects about him, even distant ones. To himself he seems to be in direct relation with these objects, but we know from physics that he sees an object only when light from the object enters his eye, and hears an object only when sound from the object enters his ears. The individual's relation with the object is really quite indirect; he does not receive the object but he receives light and sound. His skin receives heat and pressure from the environment, and his nose and mouth are affected by chemical agents. He receives these environmental forces by aid of specialized sense organs or *receptors*. The receptors arouse their nerves to activity and these *sensory nerves* arouse the *brain*. Through the brain the receptors are brought into connection with the motor nerves and so with the effectors. Quite a chain of events intervenes between the external object, as a chair, and the individual's behavior in moving the chair.

Stimuli. A force or motion reaching the organism from the environment and exciting the receptors is called a *stimulus*.

Literally a stimulus is a goad or pointed stick which arouses activity in an animal. In psychology a stimulus is any force that arouses the organism or any of its parts to activity. Light is a stimulus to the eye, sound to the ear. Though stimuli come very largely from the environment, some arise within the organism. Muscular soreness, hunger and thirst are sensations aroused by internal stimuli.

Within the organism one part may arouse another to activity. The sensory nerves arouse the brain, the brain arouses the motor nerves and they in turn arouse the muscles. When a loud sound makes you jump, the stimulus that actually reaches the muscles consists of little waves or impulses in the motor nerves.

Responses. Any activity aroused by a stimulus is a response to that stimulus. A stimulus is what arouses a response, and a response is what is aroused by a stimulus. The two terms are correlative. Notice that a response is an activity of the organism and not a passive motion. The goad does not push the ox forward but induces him to walk faster. If a heavy wave bowls me over on the beach, no stimulus-response relation is involved, but if I react in any way, as by diving or maintaining my footing, the wave arouses my response and is accordingly a stimulus. When the individual is inactive a stimulus causes him to act; when he is already active the stimulus causes some change in his activity and this change is the response.

The typical response is a muscular movement, but any activity of the organism, aroused by an external or internal stimulus, can be called a response. I hear a noise—this *hearing*, since it requires activity of the ear and brain, is a response to the external stimulus. I recognize the noise as a steamboat whistling—this *recognizing* is clearly my own act and depends on my own past experience. The boat's whistle reminds me of a vacation spent on an island—a memory response. The memory awakens a *feeling* of pleasure—an affective response, we call it—and may lead me to plan for another similar vacation. The *planning* is a response to the

pleasant memory just as the hearing was a response to the external stimulus.

The stimulus-response formula. To symbolize the dependence of activity on stimulation, a little scheme is often employed:

$$S - R, \text{ or } S \rightarrow R$$

in which S stands for the stimulus and R for the response, so that the formula reads, "A stimulus arouses a response," or, "A response is aroused by a stimulus." Whenever a stimulus is applied to an individual we can ask what response he makes, and when we see him doing anything we can ask what stimulus aroused this response.

A more complete formula. The $S - R$ formula must not be taken to mean that you can predict the response whenever you know the stimulus, or that you can secure a desired response if only you apply the correct stimulus. You have to know something besides the stimulus. Different individuals respond differently to the same stimulus, and the same individual responds differently at different times. You must know your O. Therefore a more adequate formula is:

$$S - O - R$$

This reads that the stimulus acting on the individual arouses a response, or that the response is determined by the stimulus *and* the individual.

Factors in the individual which influence his response. There are of course many ways in which one individual differs from another, or in which the same individual changes from time to time; but all these internal factors in determining the response can be brought under the three main heads of structure, state, and activity in progress.

1 *Structure.* Sometimes obviously and sometimes not so obviously, the bodily structure of O is an essential factor in all his activities. Clap your hands loudly and all the birds in the vicinity immediately take to the air, but none of the dogs or cats do so, for excellent anatomical reasons. The microscopic structure of the human brain differs from one indi-

vidual to another and changes with growth and old age, and brain structure is undoubtedly a factor in all responses. Without being able to see the internal structure of the individual, we may assume that *his relatively permanent characteristics are somehow embodied in his structure.* Heredity, previous environment and past activity, so far as they are factors in the present response, must be carried by the individual's anatomical structure.

2. *Temporary state.* Here we have a changeable factor. At one time O is tired, drowsy or actually asleep; at another time he is wide awake and keen for action; and his response to any stimulus differs according to his state. Intoxication, fever, hunger and thirst denote chemical states of the organism. We have to consider also the mood or emotional state, such as excitement, depression, anger, cheerfulness. Certainly the state of the organism is an important factor in any response.

3. *Activity in progress.* The response to any stimulus differs according to the activity engaging the individual at the moment. Stimuli that are in line with his activity get a quick response, while other stimuli may get no response at all. If he is looking for a lost ball he responds eagerly to little glints of white in the grass, which he would disregard entirely while absorbed in conversation. It is scarcely characteristic of the individual, especially the human individual, to wait passively till some stimulus arrives to wake him up. Usually he is already busy, going somewhere, interested in something, and he uses stimuli to help in his activity or else brushes them aside.

Spontaneous and forced activity. A response is neither spontaneous nor forced. It is not spontaneous because it is aroused by a stimulus, and it is not forced because it is an activity of the organism. If our $S-O-R$ formula applies to all human behavior, there can be no spontaneous activity, nor any forced activity, in the full sense of these words.

Superficially much behavior appears to be spontaneous. Someone starts up to do something with no apparent stimulus. To be sure, he is constantly exposed to a multitude of stimuli,

but we can identify no particular stimulus for his act. In spite of appearances we may doubt that his act is strictly spontaneous. There may be some internal stimulus such as a hunger pang. More likely he has been thinking and has reached a point where his thought calls for action. Even so, his act is not fully spontaneous, for two reasons. First, his thinking, like any activity in progress, was started by some stimulus. An external stimulus may arouse an internal activity which continues a long time before resulting in overt behavior. Second, when the overt behavior occurs, it must take account of the present environment; otherwise it would be inconceivably wild and ineffective. A person springs from his chair and dashes for the door; if he gets through the door he is certainly responding to present stimuli. The internal activity in progress may be as important a factor as you please; the factors contained in *O* may be as important as you please; still the *S* always plays a part. A fair conclusion would be that an act can be more or less spontaneous but never completely spontaneous.

Forced activity is often implied in ordinary modes of speech. We say we were "forced to make a detour because the main road was blocked," while we mean obviously that we were forced to make the detour *if* we were still determined to reach our destination. The external stimulus leaves us free to respond in one way or another in accordance with our internal state and activity in progress.

If you bring your hand rapidly toward another person's eyes, he is "forced" to wink. Even in such reflexes the internal factors play an essential part, as is seen from the fact that bringing your hand toward your own face does not make you wink. You are "forced" to limp by a sore foot; but your muscles and nerves are still fully capable of executing the normal movements of walking, and the limp is simply a way of avoiding pain.

Social pressures are sometimes said to mold the individual and to force him this way or that. This is not a psychological way of speaking. In sociology we can afford to think of the individual as passive because we are concerned only

to trace the effects of social forces; but in psychology we want to know what happens in the individual, and we find that he is not forced. Rather, he is stimulated. He is stimulated to avoid ridicule, to conform to the customs of the group, or at least to participate in group activities. On going to live in a new locality he picks up the accent and manners there current, not because of external compulsion, but because of his own tendency to conform and adapt himself to the environment.

SET OR ADJUSTMENT

Under the general head of activity in progress we can include the important fact that an individual often prepares to act before beginning the overt effective action. Often he could not act effectively unless he were all ready to start at the proper moment. His preparation is an essential phase of the total activity.

Preparatory set. The runner on the mark awaiting the signal to start gives a vivid picture of preparatory adjust-

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FIG. 3.—Preparatory set.

ment. His posture is *adjusted* for the quickest possible getaway. He is all *set* for the first forward movement. If his preparation were incomplete he would make a slow start; if the preparation goes a little too far he will make a false start.

Reaction time. A well-known laboratory experiment provides a similar example of preparatory set. *O* is instructed to respond to a certain stimulus by raising his finger as promptly as possible from a telegraph key. He knows in advance exactly what stimulus is to be given (usually a light or sound) and what response he has to make. A few sec-

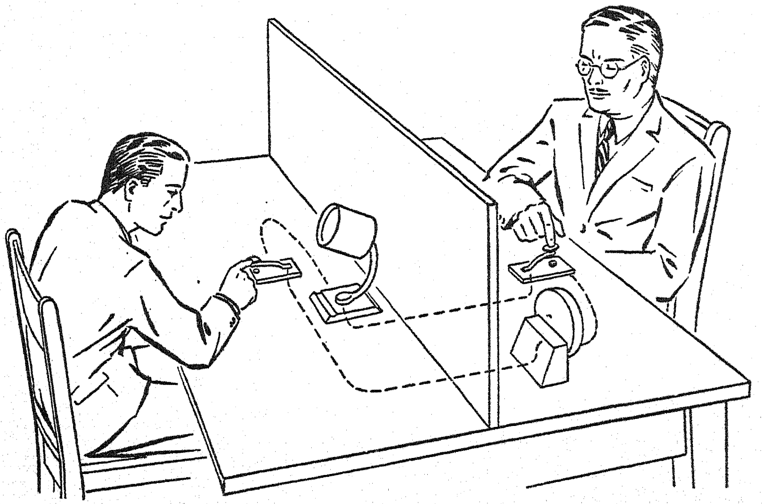

FIG. 4.—Reaction time. When E, on the right, presses his key, the neon lamp shines into O's eyes and he lifts his finger quickly from his key. The clock on E's side measures the reaction time.

onds before the actual stimulus he is given a "ready" signal, and at this signal he becomes tense, listens for the sound or looks for the light, and holds his finger poised on the key. When the stimulus arrives, his finger movement follows after an interval of less than 1/5 of a second, provided he has had a little practice, and provided he is fully ready. This stimulus-response interval is the reaction time.

What has just been described is called the "simple reaction" in distinction from other experiments that make greater demands on the subject. In the "choice reaction" he is required to respond differently to two assigned stimuli. For example, if a red light appears he must raise the right hand; but if a green light appears, the left. He cannot allow him-

self to become keyed to as high a pitch as in the simple reaction, for fear of making many false reactions. Therefore the choice reaction time is longer than the simple reaction time by about $\frac{1}{10}$ second.

The "associative reaction" is still slower. Here *O* is to name any color that is shown, or to respond to any number by saying the next larger number, or to respond to any suitable word by saying its opposite, etc. Preparation is necessarily general rather than specific and the reaction time is relatively long and variable (*4*, pp. 298-339).

The reaction time experiments find many parallels in everyday life. The motorist starting just as soon as the light changes is making a "simple" reaction. When he applies his brakes in an emergency his reaction is not so quick because, unfortunately, he has no "ready" signal and cannot get up a perfect preparatory set. The boxer, dodging to right and left according to the blows aimed at him by his adversary, is making choice reactions, and this type is very common in steering, handling tools and managing machinery. Reading words, adding numbers and many common performances demand associative reactions.

Still other examples of preparatory set are seen in the pointing dog, in the marksman taking aim, in the fielder ready to catch a fly. Whenever one knows what is going to happen, one involuntarily gets ready to take it or to do the right thing at the right time.

Continuing set, executive set, "steer." It is difficult to find just the right word for this sort of adjustment. Not only in the moment of preparing to act, but during the execution or performance of the act, the principle of set comes into play. Just as the rudder is held in position while the boat is rounding a point, an activity is steered while it is in progress. There is a continuing control throughout a series of movements. The forward-bending posture in running is a visible example, and another is the leaning toward the inside seen in a runner turning a corner. It may take him a dozen steps to round the corner, and during this series of movements he maintains the leaning posture. Numberless examples could

be given. There is the posture for carrying a load on the back, or under the arm, or in one hand. There is the searching posture in looking for a lost object on the ground. Some sets are not so visible, as when one is seeking the answer to a question, or adding a column of figures; but if one loses the set in such a task one begins to make errors. In talking you start a complex sentence, go through a long string

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FIG. 5.—Continuing set.

of words in proper order and grammatical construction, and come through to your destination. The whole spoken sentence is a consistent unit, and its unity depends on control by a continuing executive set.

Definition. What evidence have we for the reality of "set"? Sometimes it is objectively visible as posture. Sometimes the human subject is introspectively aware of his readiness for a certain act, or of a purpose continuing through a series of acts. In general, we may regard the notion of set as an explanatory hypothesis which has the merit of applying neatly to a wide range of cases. We conceive it as an active process in the organism, largely no doubt in the brain, a process which persists for a time and yet is distinctly temporary, since it changes with each new task that the or-

ganism undertakes. It works as a selective factor, favoring or *facilitating* some responses, while preventing or *inhibiting* others. Looking for a certain object is a set which facilitates the response of seeing and identifying that object. Listening is a set which facilitates the hearing of certain sounds. While listening intently you may fail to notice a visible object, the response to that object being inhibited. While looking eagerly for a lost object you do not notice sounds that at other times would surely attract your attention. Readiness for one act is at the same time unreadiness for other acts.

Mental activity, free and controlled. When you are sitting relaxed in your chair and letting your thoughts wander to things that have happened in the past or that may happen in the future, your thoughts are *free,* not directed toward any special goal. If someone asks you a difficult question and you spend a few minutes thinking out the answer, your thoughts are *controlled* by your desire to answer the question.

Even when no control is being exerted, thoughts do not come by chance. One thing reminds you of another, and often you can see the connection; often you can remember how these two things became "associated," as we say in psychology. A person, for example, is associated with the place where you met him, so that thinking of the place leads you to think of the person. When you find, as you sometimes will, that your thoughts have wandered in a few moments very far from where they started, it is an interesting psychological exercise to trace the path followed and the associations that led you on from point to point. Mind wandering is an instance of "free association," i.e., of unrestricted use of associations formed in past experience.

The free association test. Another instance of free association is afforded by this experiment. The subject is given a series of words, one by one, and is asked to respond to each stimulus word by speaking some other word. No special word is called for, but simply the first other word called up by the stimulus word. When the stimulus word is "needle," the commonest responses are "thread," "pin," "sharp," and

"sew," but many others are given by one subject or another, such as "steel," "point," "thimble." Thought is free to jump in any direction.

The *controlled association test* is conducted in the same way, except that the subject is required to respond to each stimulus word by a specified kind of word. To one series of words he must respond by saying their opposites, as "good–bad"; to another series, by mentioning a part of each object named, as "house–roof"; to another, by naming a higher class, as "sparrow–bird"; and there are many tests of this sort, each calling for one specified relation. The intelligent subject gives quick responses and makes very few errors, because he is set or prepared for the type of response to be made. On being instructed to give opposites, he adjusts himself for this type of response. His set then facilitates responses of this type and inhibits others that would readily occur in the absence of any control. The word "good" in a free association test might easily arouse the response, "good–day," "good–boy," "good–better," or many another, since all of these are common associations; but the set for opposites keeps these miscellaneous associations from operating, while it favors the "good–bad" association.

Mental work of the controlled association type. Controlled association enters into all forms of mental work—into arithmetical work, for example. A pair of numbers, such as 8 and 3, has been linked in past experience with several responses; it means 83, it means 11, it means 5, and it means 24. But if you are adding, it means 11, and no other response occurs; if you are multiplying, it means 24, and only that response occurs. The set for multiplying facilitates the responses of the multiplication table and inhibits those of the addition table, while the set for adding does the reverse. Rapid adding or multiplying would be impossible without an efficient set. Thus in arithmetic the set is a response to the *task*.

In reading, the set is a response to the *context*, and determines which meaning of a word shall actually be called to mind when the word is read. Presented alone, a word may

call up any of its meanings, but in context it brings to mind just the one meaning that fits. The same is true in conversation.

The objective *situation* arouses a set that controls both thought and action. The set of being in church, for example, controls the motor behavior to fit the occasion. The subject, observing the situation, adjusts himself to it, and his adjustment facilitates appropriate reactions, while inhibiting others.

A *problem* arouses a set directed toward solution. A difficult problem differs from a familiar task in this important respect, that the appropriate response has not been previously linked with the present situation, so that, in spite of ever so good a set, the right response cannot immediately be aroused. One must *search* for the response, but the set is useful in directing the search.

Situation set, goal set. When the individual is set for doing something we speak of a goal set. Evidently he could not act effectively without taking account of the present situation. By aid of the stimuli received he becomes acquainted with it to a certain extent, and to that extent he is adjusted or set for the situation, and we speak of a situation set.

Suppose *O* is on a journey. He comes to a strange town, looks around the place, observing the lay-out of the streets, the interesting buildings, the appearance of the people. He goes to his hotel, sleeps through the night and on awaking the next morning may for an instant not know where he is. But his situation set soon comes back. He has the town "in his head" and can go out and find his way around. This "town in his head" is not a mere jumble of impressions but a coherent framework built up by aid of the stimuli he received the day before in walking about the town. He started with a vague adjustment to the town as a whole and made it more definite by going about and observing.

If *O* has business to transact in this town, he soon ceases sightseeing and general exploring and sets himself to accomplish his task. His goal set becomes active and controls his movements. His goal set is evidently tied in with his situa-

tion set, for his movements must be adjusted to the town as well as to his purpose. We may well speak of an inclusive *situation-and-goal set,* meaning that O is set for accomplishing certain results in a (more or less) known situation.

Combined formula. We now have the background for combining the two formulas proposed earlier in the chapter. We symbolized by $W-O-W$ the active give-and-take relations between the individual and his environment, and by $S-O-R$ the fact that activity consists in making muscular responses to stimuli received. The stimuli come (largely) from the environment, the muscular responses take effect upon the environment, and the individual is set for dealing with the environment. So we obtain the final formula:

$$W-S-Ow-R-W$$

The small w attached to O symbolizes the individual's adjustment to the environment, his situation-and-goal set. The formula may be read as follows: While O is set for doing something in a certain situation he receives stimuli and makes responses, and because of his situation-and-goal set the stimuli and responses carry objective meaning, the stimuli telling him something about the situation, and the responses being aimed at objective results. For example, O is a ball player, adjusted to the momentary state of the game. He receives certain stimuli which mean to him that a fly is coming his way, and his response is appropriate to the state of the game. If his adjustment were imperfect, he would field the ball wrongly; if it were very poor, he would dodge the ball; if it were zero, he would simply stand and let the ball hit him. In general, effective action depends on good adjustment for the objective situation and for the results to be accomplished in that situation. Activity consists in making muscular responses to sensory stimuli, but at the same time, because of the individual's situation-and-goal set, it deals effectively with the environment.

Situation-and-goal set may be either preparatory or continuing. It is a preparatory set when O is ready to commence, and a continuing set when he is carrying on an activity.

SELECTIVITY

When we consider the multiplicity of acts that the individual has at his command, and the multiplicity of stimuli that strike him at any moment, we see that his activity must be highly selective. Otherwise he would constantly be performing, or at least attempting, a great medley of miscellaneous acts. As a matter of fact the organism is highly selective on the side of the stimulus and also on the side of the response.

Selective reception. The radio has made us familiar with selectivity. It can be tuned to any one of the large number of vibration frequencies that are simultaneously "on the air." The organism is selective in rather a different way. Some of its receptors are permanently tuned to one range of frequencies, some to another range, and there are wide ranges of frequency for which the organism possesses no receptors. The ear responds to air vibrations in the range from about 20 to 20,000 per second. Outside of these limits there are plenty of physical sounds but we do not hear them. The eye's sensitivity covers a very different frequency range, from 400 to 770 trillion per second. Similar physical waves of other frequencies, known as heat waves, X rays, Hertz waves, etc., do not stimulate the eye. The nose also is selective, since its receptors are sensitive only to certain kinds of substance, all others being for us inodorous.

Looking and listening movements furnish another type of selective reception. Listening is a visible performance in animals that move their ears, and man also turns his head so as to get better reception for a certain sound. Looking directly at an object brings the light from that object to the center of the retina, where vision is most distinct. The whole "field of view," including all that is visible with a fixed position of the eyes and head, is quite wide, but only what lies in the center of the field is seen distinctly.

Still another type of selective reception occurs when we "hear out" of a medley of sounds, such as a buzz of conversation, one particular sound that has some interest. We

notice the voice of one person, focus attention on it. With some effort, we can attend to a visible object without looking directly at it—a technique which the teacher of mischievous children finds it worth while to cultivate.

In these several ways, stimuli are selected. Out of the great medley of forces striking the organism, and out of the many objects present in the environment, comparatively few have any effect on the organism's activity at any one moment.

Selective response. Of many movements which the individual is capable of making, he actually makes only one or a few at any one time. Some movements are antagonistic to each other—flexing and extending the arm, approaching and avoiding an object—and only one of a pair of contrary movements is undertaken at the same time. Let there be two interesting objects in the field of view, one off to the right, the other straight upward. From the "parallelogram of forces" we might expect the eye to move in a diagonal direction, obliquely upward and to the right. If it did, neither object would come into direct vision. What the eye does is to move *either* to the right *or* straight up. The response is selective. In more complex situations compromise behavior often occurs, but the either-or type of response is quite characteristic of an organism, especially in relatively simple matters.

Shifting of response. From the principle of selectivity alone, we should expect the individual in our last illustration to turn his eyes toward the most interesting object in sight and hold them there. But he soon shifts his gaze to a second object and then, probably, to a third and fourth, and so explores the whole field. This type of behavior, too, is very characteristic of the organism. Different possible responses to a given situation are made, not all at once but in succession. Further examples of shifting between alternative responses will be given shortly under the head of attention and later in the chapter on observation.

Combination. Selectivity does not mean that each small bit of a situation is dealt with separately, nor that the motor

response is confined to one muscle at a time. Combination of stimuli and co-ordination of movements are both characteristic of the organism. A combination of stimuli works together in arousing activity, and a combination of muscles executes the response.

A complaint sometimes brought against the stimulus-response conception is that it is "atomistic." An atomistic

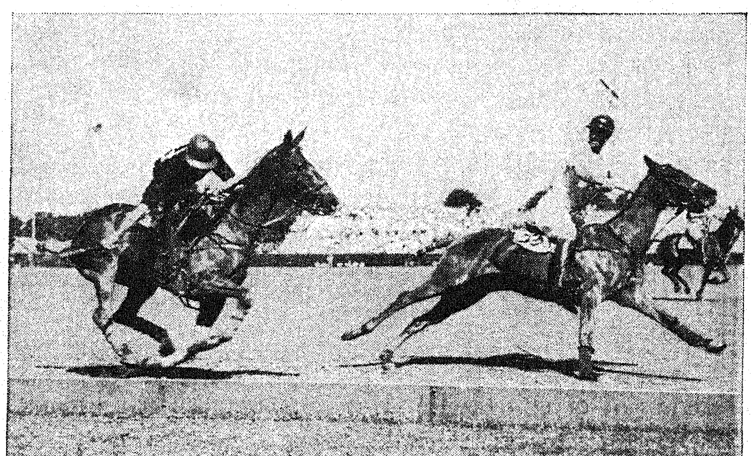

FIG. 6.—A snapshot of horses in active movement reveals positions that appear strange because in life we see the continuous movement and do not isolate the momentary positions through which the movement passes.

psychology attempts to explain any total activity by analyzing it into its elements, and this kind of explanation is sometimes felt not to get us far in psychology. However this may be, the $S - O - R$ formula is not essentially atomistic. Either S or R may be as big and complex as you like. Such a performance as lifting a heavy weight by the co-ordinated action of arms, legs and trunk is properly regarded as a single response. And such an aggregate of stimuli as is presented to the eye on looking out of the window works as a single combined stimulus when it arouses the response, "What a beautiful day!"

It is characteristic of the organism to make a unified (or unitary) response to a complex stimulus or collection of

stimuli. It is easier to see a person's face as a whole than to notice all the different parts of the face. It is easier to see the motion of a runner than to isolate the positions through which the motion passes.

Selectivity and combination would seem to be contrary tendencies and yet both are present in every activity. In seeing the whole face as a unit you at the same time isolate it from its background. It is easier to bend all the fingers at once, as in grasping an object, than to do what the young pianist has to learn with much effort, that is, to move each finger separately. Even the motion of a single finger involves the co-ordination of several muscles. But it is also true that the combined grasping movement of all the fingers is selective, for it uses certain muscles only. Not even the big movement of lifting a heavy weight brings in all the muscles, and every muscular act is selective, unless it be the general convulsion of strychnine poisoning or some other distinctly abnormal state.

The process of reading. This process affords some good examples of combination and of shifting. An old, atomistic idea was that the eyes moved steadily along the line of print, bringing each letter in turn into clear vision, and that the reader rapidly spelled out the words. But if you watch a reader's eyes (as you can do conveniently through a mirror laid flat on the table beside the reading matter) you will find that the eyes advance along the line by a series of jumps. They shift from point to point as they do in examining a scene, except that they stick to the line of print and move fairly regularly. In a newspaper line a good reader will pause or fixate about 3-6 times. Evidently his eyes are not responding to single letters (*4*, pp. 713-745).

The reaction time method shows that a short, familiar word is read as a whole. The response called for here is the reading of a single word or single letter. The reaction time is about 4/10 of a second for a single letter, and the same for a short, familiar word. Since it takes no more time to read a short word than a single letter, the word is certainly not read by a process of spelling. The word is seen as a whole. Even

a long word, if familiar, is seen as a whole. A child can learn to read words before he knows his letters, and he can even recognize whole phrases and sentences before he has learned the separate words, just as he recognizes a face without analyzing it into its parts.

The speed of silent reading is much too great to allow time for separate reactions to the successive words, let alone the letters. Easy reading by adults goes at the rate of 2.5 words per second in a slow reader, and as fast as 10 words per second in a rapid reader. Difficult material is read more slowly because time has to be allowed for comprehension.

What are the limiting factors in speed of reading, and why is one individual's limit so much lower than another's? Speed of comprehension is probably the most important factor. Difficult material holds you back, while easily grasped and interesting material pulls you ahead. Comprehension evidently depends on knowledge already in the reader's possession. A trained psychologist will read this book about as rapidly as he reads a novel. Given the same background of knowledge, however, two individuals may read at quite different rates. One may be mentally quicker than the other. But shall we conclude that the slow reader is necessarily less gifted with native intelligence and therefore forever doomed to remain a slow reader? Not at all. He may not realize that he is a slow reader. He may even prefer to read slowly so as to savor each passage to the full. Still he is missing something if he is not able also to read rapidly. Some material that is not worth a lot of the reader's time may be read rapidly for pure enjoyment or for culling out a few ideas. It is one thing to spend an hour or two on a detective story, and quite another thing to let it keep you awake all night.

No single prescription can be given to all slow readers who wish to improve. Some have one bad habit, some another. Some have carried over from childhood the habit of whispering the words or at least moving the lips. Now the maximum speed of oral reading is much less than that of silent reading, so that a reader who has not eliminated most of the motor activity of oral reading is driving with the brakes on. Some

adults continue to examine the words minutely as the beginner may have to do, while others have the opposite habit of skimming too hurriedly over the words, misreading some of them and having to go back. Some adults have a very insufficient vocabulary for reading adult material. Some, because of their very slowness, have acquired a distaste for reading. Some have never mastered the technique of eye movements and may profit from special exercises designed to regularize these movements and to reduce the number of fixations per line of print. The main thing usually is to convince the slow reader that he has something to learn, something well worth while to which he should give some attention with the confident expectation of making a considerable gain. When all is done, some individuals will continue to read more rapidly than others.

Reading affords a clear example of the formula, $W - S - Ow - R - W$. Here S is the printed page or, more precisely, the light reflected from the page into the eyes. R covers the motor responses of the eyes and of the speech organs, and also the intellectual responses of comprehension and the affective responses of enjoyment, disgust or whatever emotion may be aroused. All these responses depend on the stimuli received from the printed page, and they depend also on factors present in O: his training, experience and knowledge; his present state, wideawake or drowsy; and his interest. After the reading has got under way it is obviously an activity in progress, and the reader becomes set or adjusted for the situation portrayed in the story and for the "goal," the outcome of the story. He becomes set for the context, and this set is very important because so many words have a variety of meanings (see the dictionary!) which would confuse the reader except for the selective influence exerted by the context through O's set. Actually, each word conveys to him the meaning that fits the context and usually no other meaning. W, in case of a news item, consists of the objective events reported. There is all the difference in the world between the printed page, with its rows of funny little characters, and the incident which the reader gets from the page. The reader is

scarcely aware of the page and the little characters, so absorbed is he in the meaning. It is a good example of dealing with the environment rather than with the stimuli actually received.

THE PSYCHOLOGY OF ATTENTION

The very practical subject of attention can well be introduced here, because the laws of attention are in the main the general laws of activity which we have already noticed. In particular, attention illustrates the principles of selectivity and set.

"Attention" is one of those nouns that are properly verbs. We need not assume the existence of any separate faculty of attention or of any special brain center exerting the power of attention. What we find is the individual attending or not attending to a certain object, line of thought, or motor performance. To attend is to concentrate activity in one certain direction, at least for the moment. Attention shifts, but at any one moment it is focused on one object as against other possible objects; or it is focused on an act that we are performing as against other acts that we might be doing, or even that we are doing inattentively. Attention is selective.

Doing two things at once. According to the principle of selectivity we might suppose that the organism could engage in only one activity at the same time, and yet we are usually doing at least two things at once, one being the act of breathing. We have no trouble in breathing and walking at the same time nor in thinking while both walking and breathing. But breathing and walking are so automatic as to require no attention. The significant question is whether two acts can be *attentively* performed at the very same time.

Julius Caesar, it is said, used to dictate at once to several copyists. As his copyists were not stenographers, he could give the first a start on one letter, pass to the second and start him on another letter, and so on, coming back to the first copyist in time to keep him busy. Quite an intellectual feat, certainly; but not a feat requiring absolutely simultaneous

attention to several different matters. You can add a column of numbers while reciting a familiar poem; you get the poem started, let it run on automatically for a few words while you add a few numbers, switch back to the poem and then back to the adding. But in all this there is no doing of two things, attentively, at the same instant of time.

Laboratory experiments have required *O* to add columns of numbers while listening to a story. At the end he tries to reproduce the story, and his performance is scored for adding and for memory of the story. On the average, he does about 60 percent as well in these simple tasks combined as he could do in performing them separately. Individuals differ greatly in their ability to distribute attention in this way; but those who succeed do so by efficiently shifting back and forth between the two tasks (p. 38).

Besides this shifting, there is another way in which two simultaneous tasks can sometimes be carried on. They may be *combined* into a single meaningful performance. The beginner at the piano likes to play with the right hand alone, because striking the bass note with the left hand distracts him from properly playing the "air" with his right hand. After some practice he can couple the two hands and strike air and bass at once, much to his satisfaction. This is an example of motor combination or co-ordination.

Whether we shift from one task to the other, or combine them into one task, in neither case do we perform two separate acts attentively at the same time. We can attend to a complex object like the face, containing many parts, but we attend to it as a unit. If we try to attend to two distinct objects, we may shift back and forth between them or we may be able to group the two in some interesting way, as when we notice a queerly assorted pair of persons. We can see a flock of pigeons as a whole, and we can group and combine objects to almost any extent, but to keep two objects distinct and unrelated and still to attend to both at once seems as unnatural as looking in two directions at the same time. So we come back to the principle of selectivity, admirably illustrated by the facts of attention (*4*, pp. 684-712).

Degrees of awareness or consciousness. These two nouns are properly adverbs or perhaps adjectives. Some physiological activities, such as those of the internal organs, are carried on unconsciously, without *O*'s being aware of them. The total activity of the organism at any moment can be divided into three fields: the field of unconscious activity, the field of vague awareness, and the field of clear awareness. The latter is also called the field of attention. It includes the object we are observing or the act we are attentively performing. If selectivity were absolute, there would be no field of vague awareness. When we were looking attentively at one object, the rest of the field of view would vanish and we should be totally unaware of the street noises and of pressures on the skin. The fact is that we are dimly aware of much that is going on outside our momentary field of attention. The field of vague awareness is wide rather than narrow. It includes our feeling of well-being or strain, our sense of where we are and what we are doing (situation-and-goal set) and other background matters.

Catching and holding attention. Though on occasion we attend to every kind of object—large or small, new or old, pleasant or unpleasant—we are more likely to attend to some things than to others. The question is what factors give the advantage to one object over another. The $S-O-R$ formula will serve as a guide in seeking the answer. Let R be the response of attending. What factors in S and O give the advantage to one object or another in catching and holding attention?

Certain characteristics of the *stimulus* give it the advantage in attracting attention.

Strength or intensity of the stimulus is an important factor. A strong stimulus, other things being equal, will be noticed rather than a weak one. A loud noise has the advantage over a low murmur, a bright flash of light over a faint twinkle. In the case of visible objects *size* has about the same effect as intensity; the large features of a landscape are noticed before the finer details.

Repetition is another factor. Repeat a call several times in

quick succession and it is surer to be heard. Repeat a figure in the decoration of a building and it is more impressive than if used only once.

If however a stimulus is repeated many times, it ceases to hold attention because of its monotony. It yields its hold to some other stimulus that has the advantage of change and novelty.

Change is perhaps the greatest advantage that a stimulus can have. A steady noise ceases after a while to be noticed, but let it change in any respect and immediately it arrests attention. We become used or habituated to the steady ticking of a clock, but wake up with a start if it stops. A moving object is very apt to catch the eye. Anything novel or unusual arouses suspicion or at least attention.

So much for the stimulus-factors. The factors present *in the organism* that determine the direction of attention may be classified, according to our previous analysis, into permanent or structural factors, and temporary factors of state and activity in progress.

Permanent or habitual factors depend on *O*'s previous experience and training. He has learned what is worth noticing and what is not and so has built up *habits of attention and inattention*. The automobile driver acquires the habit of listening to his motor, since the sound indicates whether the motor is laboring or running freely. The botanist becomes attentive to such very inconspicuous objects as the lichens on the trunks of trees. Habits of attention are established in the child by the influence of other people, who point out to him what they regard as worth noticing. He becomes acquainted with the things that other people know, and in this way his knowledge of things follows traditional lines.

The *emotional state* of the moment is a factor in directing attention. When you are angry or disgusted with a person you notice his bad points more than at other times.

Activity in progress is probably the most important factor of all. The *interest of the moment* indicates the activity in progress, and stimuli in line with this interest are especially

apt to get attention. What you shall notice in the show window depends on what you want to buy as well as on the prominence of different articles in the display. The interest of the moment sometimes takes the form of a question. Ask yourself what spots of red are present in the field of view, and immediately the red spots jump at you. Ask yourself what pressure sensations you are getting from the skin, and immediately several obtrude themselves. A question is a set of the organism for finding the answer.

To catch attention is one thing, to hold it is another. The stimulus-factors such as intensity and novelty attract attention, but some genuine interest must be tapped in order to hold attention for long. The stimulus-factors are important for anyone who desires to catch the attention at a certain time and place. When a speaker wishes to wake up his audience, he may use the factor of intensity, by shouting, or he may rely on the factor of change and speak slowly or even softly. Street signs struggle to make effective use of these stimulus-factors. Illuminated signs use intensity; flashing signs use change and repetition; striking color is much in evidence, and the big signs outbid the smaller ones. Newspaper and magazine advertisers competing for the reader's attention use similar devices. A picture, especially one with people in it, is often effective in catching the reader's attention for a moment. But to hold the attention the advertisement must appeal to his interest. If he is hunting for a job, even a little "want ad," with all the factors against it except the factor of interest, will surely catch the eye and be carefully examined.

Attentive sets and postures. When the military officer shouts "Attention!" or when the athletic starter calls out "Ready!" the command puts the parties concerned in readiness for what is coming next. It arouses an expectant attitude, a preparatory set, which shuts out miscellaneous stimuli and responses and clears the deck for action.

A continuing set is visible in the postures of an audience absorbed in a speech. Most people look fixedly toward the speaker and many of them lean forward as if it were im-

portant to get just as close as possible. All the little restless movements cease and at the tensest moments even the breath is suspended. The posture is immobile with the whole body directed toward the object of attention. When attention is focused not on anything present but on something thought of, a somewhat different posture is often adopted, with the trunk leaning forward, the neck stiff and the eyes staring at vacancy. These immobile, strained postures are not essential but may play a part in shutting out extraneous stimuli and enabling the listener or thinker to concentrate fully on the matter of interest.

Shifting of attention. Eye movements afford a partial picture of the great mobility of attention. Ordinarily the eyes shift about from one thing to another. It is almost impossible to hold them fixed for any length of time on a simple, unchanging object. And even while the eyes remain fixed on the same object, attention is likely to shift from one part of the object to another, or from its color to its shape, or entirely away from the object to some interesting thought. Look fixedly at a short word and notice how difficult it is to prevent various thoughts from obtruding themselves. Or try to attend continuously to a single idea such as "It may rain tonight."

Attention is mobile, exploratory; it continually seeks something fresh for examination. In the presence of a novel situation, it tends to shift every second or two from one part to another. Even while one is lying in bed with the eyes closed, the movement of attention still appears in the rapid succession of thoughts and images.

Sustained attention. It would almost seem that the possibility of sustained attention was excluded by the facts of shifting and mobility just mentioned. Yet an exciting game certainly holds the spectator's attention. Not for an instant does his mind wander. For all that, his attention is as nimble as ever. He keeps pace with the game which is certainly mobile and changing. His attention sticks to the game but moves with the game. To sustain attention is to concentrate one's activity continuously upon some object or happening

or problem. Sustained attention, in most cases, is less like a rigid posture than like the act of going to get a desired object. There is no wandering but there is a series of steps. There is an activity in progress, controlled by a persistent set. It is the small w in our $W-S-Ow-R-W$ formula that sustains attention. It is the factor of interest, desire or determination.

Distraction. Whatever you may be doing there are other interests or other external stimuli competing for attention. If they catch your attention you are distracted, and anything that turns your attention away from the matter in hand may be called a distractor.

Distraction is a favorite theme for experiments, because of the light thrown on sustained attention. The usual result is that the supposed distractor fails to distract. One typical experiment (*2*) followed the method of "matched groups." First a paper-and-pencil intelligence test was given to a large class of college sophomores, and from the class two groups were so constituted that for each student in one group there was a student in the other group who made the same score in this preliminary test. Each group contained 90 students. Some weeks later these matched groups took another similar intelligence test, the experimental group under distracting conditions, the control group under normal conditions. The distractors were bells, buzzers, organ pipes, whistles and other loud noises, intermittent music, a spotlight flashing around the walls of the room, and people moving roughly about, talking and carrying strange apparatus. The conditions were outrageous, except that the whole thing was an experiment. The average scores came out as follows:

	Points
Control group, working in quiet	137.6
Experimental group, working under distraction	133.9
Loss through distraction	3.7

The effect of distraction was very slight on the average, and none of the students broke down in the 19 minutes of intense work under severe distraction, though a few reported considerable strain.

Another experimenter (*1*) used the method of alternating the same *O*s back and forth between normal and distracting conditions. Here also the effect was rather slight and it could be warped one way or the other by suggestion. If the subjects were led to believe that dance music would disturb arithmetical work, they lost a little; if they were led to believe that the music would facilitate the work, they gained a little; without any such suggestion they neither gained nor lost. Some students say that soft radio music helps them to study; this also may be an effect of suggestion.

The students in these distraction experiments are of course on their mettle, and they have little to lose by disregarding bells, buzzers or even some music. Another investigator (*3*) employed distractors that had more intrinsic interest. He presented beautiful music and humorous anecdotes while his subjects were adding, memorizing, or solving riddles. Every one of the 16 subjects showed some loss of output, ranging from 8 to 50 percent. Sometimes they lost track of their work and gave themselves up for a time to the story or music. At other times they fought off the distractor by a great expenditure of muscular energy. Better than fighting off the distraction was a renewed positive concentration upon the work.

So much intellectual work is done nowadays in noisy surroundings that the question whether work under such conditions makes a steady drain on the organism is very important. Further investigation is needed before this question can be fully answered. Much depends on *O*'s emotional reaction. If he is irritated to the point of thinking, "Such conditions are wicked and ought not to be allowed," his work will probably suffer. Internal distractions such as anger, fear, boredom, feeling of fatigue, or interesting thoughts unrelated to the matter in hand have more effect than the everyday external distractors.

Teachers sometimes complain of inattentive pupils, and students are known to complain of their own poor powers of attention. The trouble with the children is not inattention in an absolute sense, but *attention to something else;* and this

is usually the source of the students' difficulty, too. There is such a thing as a diffuse, trance-like state in which activity is not concentrated in any direction. But with live young adults the question is how to sustain attention in spite of conflicting interests. We can learn something here from story reading. Dawdling over an exciting story is unusual; the reader forgets his other interests and presses forward eagerly to see how the story is coming out. The efficient reader of serious matter has a similar eagerness. He sees the question at issue and presses forward to find the answer. Such a reader is both quick and retentive.

For the student the ideal sustainer of attention is of course a genuine interest in the subject. Any branch of science, art or literature is extremely interesting, once we get into it, but we may have to force our way into it by utilizing personal motives such as fear of failure, love of applause or determination to master the task we have undertaken.

For the speaker or writer, the problem is to awaken in his audience some question or forward-driving interest in the subject, and then to lead on to the answer without too many detours. Side issues which seem interesting to the author tend to lead the reader astray, and even illustrative examples, concrete and interesting though they may be, are likely to confuse the reader. He often remembers the example but forgets the point it was intended to illustrate. The main requirement is to get the right activity started and to assist its progress toward the goal.

SUMMARY: GENERAL CHARACTERISTICS OF THE ORGANISM'S ACTIVITY

What we have discovered in this chapter can be largely summed up in a list of characteristics of the individual's activity.

1. The organism though an extremely complex system is nevertheless a unit and behaves as a unit in dealing with the environment.

2. The organism is dependent on the environment for en-

ergy (food and oxygen), for stimulation and for outlet or opportunity for action.

3. In many ways the organism resists the forces of the environment. It participates as a relatively independent unit in what goes on in the environment.

4. The organism is drawn into active relations with the environment through the medium of stimuli that arouse its receptors and of responses executed by its effectors.

5. Connection between effectors and receptors is provided by the nervous system.

6. The *S—R* formula embodies the principle that the forces of the environment act as stimuli; that is, in behavior the organism is not passively moved but is active, its activity being however aroused or changed by stimuli. Some stimuli arise within the organism. Any activity or any change of activity is a response.

7. The *S—O—R* formula embodies the principle that the response is determined not only by the stimulus but also by factors lying within the organism, which can be classified as follows:

- a. Bodily structure, dependent on
  - (1) Heredity
  - (2) Previous environment
- b. Present state of the organism
  - (1) Chemical state
  - (2) Emotional state
- c. Activity in progress, including situation-and-goal set

8. The *W—S—Ow—R—W* formula embodies three principles:

- a. The organism deals effectively with the environment.
- b. It deals with the environment only through the medium of stimuli and responses.
- c. Essential to effective dealing with the environment is an adjustment of the organism for the objective situation and for objective results to be achieved by its activity.

9. Behavior is selective. At any moment the organism responds only to some out of many present stimuli and executes only some out of many possible responses.

10. For all its selectivity the organism usually responds to combinations of stimuli. It makes a unitary response to a combination of stimuli.

11. Even when the external situation remains the same, the organism characteristically shifts the center of its activity from one object to another or from one response to another.

12. In spite of this shifting, sustained activity along a certain line or directed to a certain goal is very characteristic.

13. These behavior characteristics are present in attending and can be introspectively as well as objectively observed. One is aware of the environment and of what one is doing in the environment, rather than of stimuli and responses in the strict sense. One attends or concentrates on one object at a time, leaving others in the background of vague awareness. The focus of attention is apt to be a large total object rather than a small part, and to shift even while attention to a general topic or problem is sustained.

Some of these principles have been illustrated by experiments on reaction time, free and controlled association, reading, distraction, and the factors of advantage in attention.

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Chapter III

Individual Differences in Ability

IN DAILY life we get along quite well by making two contrary assumptions regarding our fellow men: first, that they are all much alike, and second, that each one is different. When several people are looking at the same scene, we assume that they see about alike; and when they are listening to the same speech we assume that they all hear and understand about alike. And so they do, but only in a general way. One person has better eyes than another and sees the scene more distinctly, or he may have his own special interests and for that reason notice details that others overlook. One person, more than another, has the background for understanding a speech in all its implications. Such differences between individuals are often brought home to us forcibly, and we readily admit that social life has much more spice because individuals differ. At the same time social life would be impossible except for common interests and except for the fact that we all see, hear, think and feel pretty much alike under the same circumstances.

Psychology, then, has the double duty of showing how individuals are alike and how they differ. So far, our preliminary survey of the individual in his environment has been concerned with "the" individual, i.e., with ways in which individuals are alike. Later on we shall return to this side of the subject and look for general laws of learning, remembering, perceiving, thinking, feeling and acting. For the present, however, and for several chapters, we shall follow up the important fact that individuals differ in ability and personality.

Convinced without more argument that individuals differ, the reader may be impatient to advance at once to the question why they differ. Is it heredity that makes them different, or environment? Partly the one and partly the other, in all probability. But before coming to grips with this difficult question, as we shall later, we must have a fuller and more exact knowledge of the facts to be explained. The facts of individual differences are important even though science has not yet reached a complete explanation. The differences turn out to have some law and regularity and to be very instructive when carefully examined.

When a person is described as "a very able individual," or another as having "little ability," there is an underlying assumption that individuals differ in general, all-round ability. Quite a different assumption is implied when a politician is said to possess great oratorical ability but little ability in administration, or when an athlete is said to have greater ability in running than in pole vaulting, or when a person is said to have a gift for salesmanship or for millinery. There seem to be many special abilities and the question is whether there is any such thing as general ability. This is one of the questions to be investigated in a scientific study of individual differences.

ABILITY AND CAPACITY

To say that a person possesses the *ability* to do a certain thing amounts to saying that he *can do* it. He can do it without further development or training. One who possesses the ability to add a column of figures can sit right down and add them. One who possesses the ability to speak French can start in at once and do so. A visitor to Paris was amazed at the "wonderful ability of the French children." They spoke the French language with such ease and fluency! Now of course, from lack of training, children in other countries do not possess this particular ability, but probably every normal child the world over has the *capacity* to speak French. The distinction between ability and capacity is very important. An ability is ready for use, a capacity needs training. To

say that an individual has the capacity to do something amounts to saying that he *can learn* to do it.

Anyone's capacity exceeds his ability, since he is not trained to his limit in every line, and probably not in any line. No one has learned all he is capable of learning, unless perhaps he is very old or somehow incapacitated. But capacity itself is not unlimited. No human being, probably, has the capacity to run a mile in three minutes, for many fine runners have subjected themselves to intensive training but no one has approached any such record. A child's capacity, for the time being, is limited by his immature stage of development. With further development his capacity for both muscular and mental performances will increase. But his ultimate, mature capacity also is limited and the limit is different for different individuals as we see clearly in athletics. Ultimate capacity is limited also in mathematics or artistic creation or any mental achievement.

Evidence for ability and capacity. When we say that an individual has a certain ability, i.e., can do a certain thing, our clearest evidence is that we have seen him do it. The only direct evidence of ability is actual performance. Sometimes we accept indirect evidence as sufficient. We assure the two-year-old he can blow out the candle because we know that most children of his age can do so after a few trials. We might be mistaken in the individual case but we have probability on our side. We say of a woman that she cannot sing bass, without having heard her try, because women seldom reach the lower bass notes. So we infer the probable ability of one individual from the actual performance of comparable individuals.

Let us ask ourselves what a man "possesses" when he has the ability to sing bass. At a given moment he is not singing, and yet he has the ability. His ability lies in his possession of a large larynx, with mouth and throat to match, and with some degree of skill in managing these organs. The mouth, throat and larynx are parts of his bodily structure, and his skill is doubtless dependent on structure, especially brain structure. Acquiring skill—learning—must modify the struc-

ture of the organism in some respect. Ability therefore resides in organic structure, but as we cannot practically observe a living man's brain structure our evidence of his abilities always comes down to a matter of observed or probable performance.

Evidence for capacity, i.e., for undeveloped, untrained capacity, is bound to be indirect. If we are asked whether a given child has the capacity to speak French, we can safely answer, "Yes," because all normal children in a French environment do learn to speak French. But if we are asked *how much* capacity this child has for speaking French we need to be cautious, since individuals who have had the best opportunities and training differ greatly in their ability to speak French. Their capacities evidently differ. In any line of activity—athletic, musical, literary, practical—individuals who have subjected themselves to the most intensive training come out with unequal abilities, and we infer that they must have started with unequal capacities. If capacity could somehow be estimated in advance of intensive training, much wasted effort could be spared. The estimate would necessarily be based on indications that are not perfectly dependable. Give a number of individuals a small amount of training in a certain line and see how they compare at this early stage. Continue practice and see how they come out at the end. Those who started well usually continue well and those who made a poor start usually remain relatively poor. But there are many exceptions, so that prediction from the early indications is only fair, not perfect by any means.

TESTS FOR MEASURING ABILITY

Ability lends itself to quantitative study, since, while many individuals may perform the same task, one does it better than another. We can measure ability by actual performance, provided we can measure the performance. In attempting to measure abilities psychologists have devised standardized tasks to be performed under standardized conditions. Such a task, so administered, is called a test. Some

tests are much like laboratory experiments and demand elaborate apparatus; for example, the reaction time test. Other tests demand only pencil and paper as apparatus and resemble ordinary school examinations except that the questions are prepared with unusual care and that the score for every possible answer is worked out in advance. In the process of standardization the test material is tried out on a preliminary group of subjects so as to discover ambiguities which need to be eliminated and so as to determine the best time allowance and the amount of explanation required to start the subjects on the right track. Many tests for children have been tried out on a grand scale, and age and grade norms have been worked out. An age norm is the average score made by children of a certain age, a grade norm the average made by children of a certain school grade.

In "speed tests" the task is very simple and the question is how rapidly an individual performs it. The color-naming test (see Frontispiece) presents several familiar colors, repeated many times in shuffled order, and the subject is instructed to name the colors in their order and as rapidly as possible. Individuals differ considerably in the speed of this simple performance, and it is interesting to notice that women, on the average, are definitely quicker than men in this color-naming particular task. In "accuracy tests," such as throwing darts at a target, or bisecting a line by the eye, or comparing weights lifted by the hand, the amount of error is measured. In "difficulty tests" no emphasis is placed on speed; the test items run from easy to hard and the difficulty level which the subject reaches is determined. For example, the subject is asked to give the opposite of each of a list of words, such as the following:

good	soothing
early	stubborn
north	helpless
beautiful	lonesome
gentle	resentful
vague	remarkable
doubtful	sticky

In scoring such a test, no credit is allowed for very undiscriminating responses (such as "bad" given as an opposite for gentle), though half credit may be allowed for fair approximations ("cruel"), with full credit only for exact opposites ("violent"). The points of credit are counted up to get the *raw score.* In a target test the raw score would be the count of bull's-eyes plus partial credits for less accurate hits. In reaction time, the subject would be given a number of trials and the raw score would be his average time.

A raw score just by itself tells you nothing about the individual's ability. The author once put a piano virtuoso through a series of tests, including the simple reaction time to sound. The reaction time was $\frac{1}{10}$ of a second. Was this quick or slow? The pianist regarded his performance as a failure. "I can't do it," he said after repeated trials. He was obviously trying to come in on the beat, as he could in a concert, once the conductor had established the rhythm by a few preliminary strokes of the baton. By catching the rhythm the players are able to synchronize their responses and to eliminate the reaction time altogether—otherwise we should hear very sloppy music. Lacking any rhythm to help him in the laboratory test, the pianist was forced to show a reaction time. But his time of $\frac{1}{10}$ second flat, in comparison with other individuals, was remarkably quick, practically unsurpassed. A raw score becomes meaningful when it is compared with the scores of other individuals in the same test. When the whole population, or a fair sample of it, has been tested, the individual can be located as slightly below average, far above average, etc. The pianist was far superior to the average in speed of the simple reaction to sound. Can we conclude that he was a very quick individual in general? No, we cannot take the reaction time as a sure index of quickness in general. Investigation has shown that some who are quick in this test are slow in other tests, while some who are slow in the simple reaction are quick in more complex performances.

In evaluating the significance of any single test score the psychologist, as just illustrated, is drawn into extensive in-

vestigations of a statistical nature. He needs to compare the individual's score with the general run of scores in the population. He tests a fair sample of the population, or of some definite class of people, such as twelve-year-old children, or adults in general, or college students. He finds the *average* score for the group. He also needs to know the *scatter* of the group—how much the individuals differ from one another. So far, his problem is that of measuring the *distribution* of a single ability. His second main problem is that of *correlation*, the relationship of different abilities. How closely are they related? For example, will a single test such as the reaction time serve as an index of a large sector of human ability, or is it very narrow in scope? A few of the statistical techniques for handling distribution and correlation will be mentioned at the end of the chapter. But our own interest lies wholly in the results, not in the statistical methods which can be found in excellent special books (*6*, *7*, *8*, *9*).

THE DISTRIBUTION OF ABILITY

Individuals differ in every ability that has ever been tested. Adults differ, ten-year-olds differ, newborn babies differ. They differ widely but not wildly. The first regularity to notice is that the *range* of any ability (the whole distance from the best to the poorest) is limited. The range of reaction time to sound, after a little practice, extends from about 1/10 to about 2/10 of a second. The time for naming 40 easy opposites ranged in a large group of women college students from 35 to 80 seconds. In a memory test these same students studied a list of 25 unrelated words for one minute and then wrote down all the words they could remember. The range extended from 6 to 18 words (*3*).

The range, we say, is limited. But the limits are not exact and sharp. If more individuals are tested, someone may be found to fall somewhat outside the range as previously determined. And the range will change with conditions, as with practice. If you test 100 students in a certain ability, the scores scatter over a certain range. Train them and test

again; all the individuals have probably improved, so that the range has moved in the direction of greater ability. It may have become somewhat wider or narrower; in any case it will still be considerable; for though training and education may increase everyone's ability they do not destroy individual differences.

Measures of the distribution. Say you have put 100 individuals through a test and wish to state the results compactly and intelligibly. You could state the upper and lower limits of the range. You could assume the halfway point between these limits for the center of the distribution, and you could use as a measure of scatter the whole extent of the range. So you would convey some idea of your results. But these measures would not be very accurate or reliable, because they depend entirely on the two end men, the best and the poorest in your sample. Your measures should take full account of every individual's score in the test. The best measure of the center of the distribution is the *average*, obtained by adding all the scores and dividing by their number. The best measure of scatter is the *standard deviation*, symbolized by the letters *SD*. The *SD* takes account of every individual's deviation from the average. (For computation of the *SD*, see the statistical supplement at the end of this chapter.)

The individual's position in the distribution can be indicated roughly by locating his score in its place along the range; it may be near the top, near the middle, near the bottom. A more exact statement is afforded by the *SD score.* The individual's *SD* score is his distance above or below the average, measured in terms of the *SD* as a unit, as will be further explained in the statistical supplement. The *SD* score shows exactly where the individual stands in the group as a whole.

The distribution curve. Represent the range of a certain ability by a horizontal line with the best individual standing at one end and the poorest at the other end, and locate every individual somewhere within the range according to his test score. The individuals will scatter over the range, but not

evenly. There will be many near the middle and fewer and fewer toward each end of the range.

When a large number of individuals have been tested, the

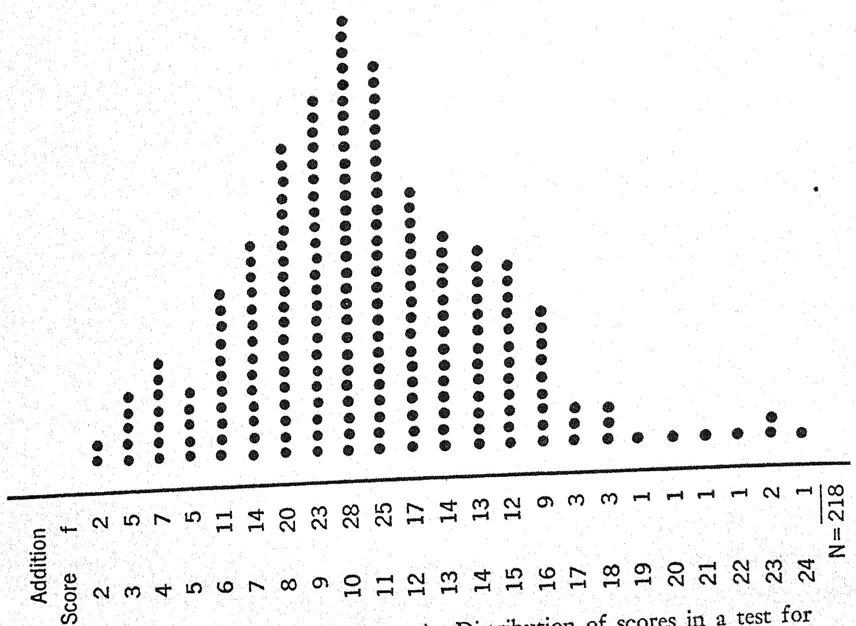


FIG. 7.—(Data from Thurstone, *14*.) Distribution of scores in a test for speed of addition. Three minutes were allowed for adding columns of 2-place numbers like this example:

18
56
43
88
37
22
65

The test sheet provided 24 such examples, and the score was the number right. The subjects were 218 college students. *f* is the number of subjects making each score.

piling up near the middle and tapering off toward the extremes give the whole distribution somewhat the shape of a bell. Actual examples are given in Figs. 7 and 8, where each dot represents the score of one individual and shows his standing in relation to the others. The 28 individuals who got 10 addition examples right are seen to stand about

in the middle of the group; the 9 individuals who scored 16 examples stood well up toward the head, as only 13 individuals, 6 percent of the group, surpassed them.

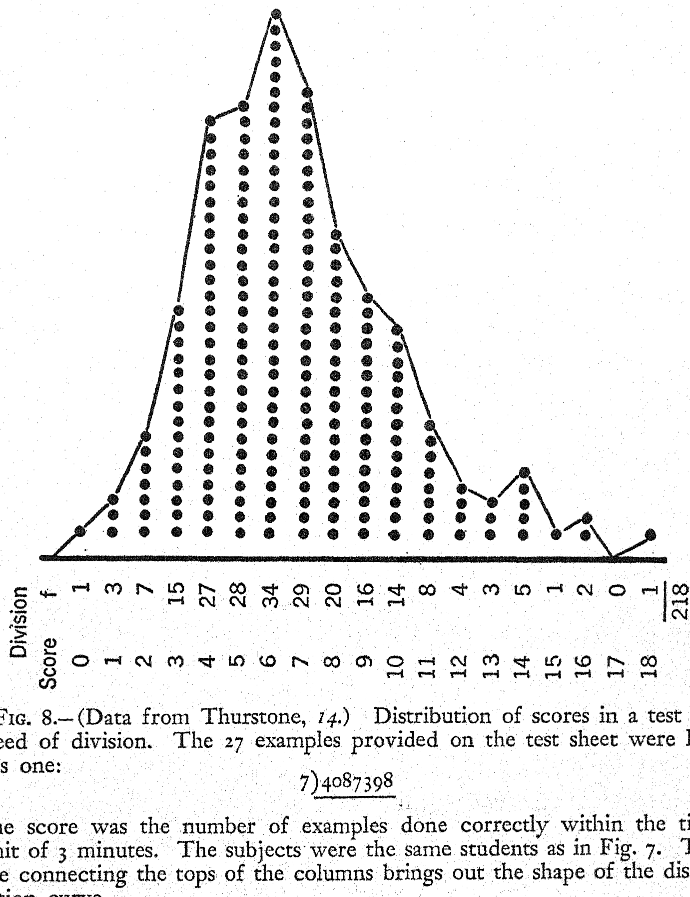


FIG. 8.—(Data from Thurstone, *14*.) Distribution of scores in a test for speed of division. The 27 examples provided on the test sheet were like this one:

$$7\overline{)4087398}$$

The score was the number of examples done correctly within the time limit of 3 minutes. The subjects were the same students as in Fig. 7. The line connecting the tops of the columns brings out the shape of the distribution curve.

If we outline the shape of the distribution by a line joining the tops of adjacent columns we have the *distribution curve*. Such a curve can be smoothed by disregarding minor irregularities, which would disappear or change with increasing numbers of subjects tested. The height of each column shows the *frequency* or count of individuals who made a certain score. The most frequent score, indicated by the highest part of the curve, is called the *mode*.

In a *normal* or symmetrical distribution the mode falls in the center of the range and coincides with the average.

Skew distribution. The two large distributions here shown are somewhat unsymmetrical. The mode lies to the left of the middle, because a few individuals made very high scores and extended the range in that direction. Such skew distributions occur quite often and are due to a variety of interesting causes. One cause for the skewness in arithmetical ability is rather obvious. Most children in school are contented with moderate achievement in adding or dividing, while a few, finding this activity easy or fascinating or practically important for them, work up a superior technique. Aside from such special causes the distribution of psychological scores is approximately symmetrical and normal.

Bimodal distribution. Consider, however, what distribution to expect when the group tested consists of two very different subgroups. An example is shown in Fig. 9. The

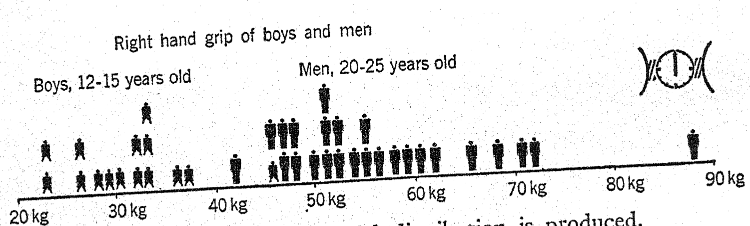


FIG. 9.—How a bimodal distribution is produced.

dynamometer test for strength of grip was given to boys of 12-15 years and to young men. The men, naturally, were stronger than the boys. When the two distributions are thrown together, we see two distinct modes, one in the region of 35 kilos for the boys, and one near 52 kilos for the men. The combined distribution is bimodal. Whenever we find a definitely and surely bimodal distribution, we suspect that our group is composed of two subgroups differing in age, training or attitude.

The question of "mental types." A type, in the sense used here, is a class of individuals who have the same general characteristics, though they may still differ somewhat in the

degree to which they possess these characteristics. They all cluster around the same mode, and the individuals who are exactly at the mode are the most typical. Now the question is whether, aside from differences due to age, sex or special training, the population naturally falls into two or more types, or whether they all cluster around a single mode and belong to the same type.

From childhood up we are accustomed to the use of opposites: large and small, short and tall, blond and brunet, bright and dull, good and bad. If a person isn't good he must be bad; if not bright, he must be dull; if not tall, then short. It is quite an achievement to get beyond this either-or style of thinking so as to recognize an intermediate class of medium people—medium in height, or in intelligence, or in character. But having gone so far we can hardly stop short of admitting a *continuous gradation* in height from the shortest to the tallest, and similarly in the other characteristics. This way of regarding people as graded continuously between the extremes is certainly fortified by test results, for the scores in any fair test cluster around a single mode and taper off in frequency toward either extreme—provided, of course, enough individuals have been tested to avoid chance irregularities, and provided also no special factor of age, training or attitude divides the group.

Imagery types? The fact that individuals differ greatly in their ways of thinking of an absent object or scene was established in 1883 by Francis Galton, who more than anyone else was the founder of the science of individual differences. Galton set up in London an anthropometric laboratory for obtaining physical and mental measurements of many individuals and so obtaining data for the study of heredity and environment. He devised a number of psychological tests. His imagery questionnaire was not exactly a test, since it was of necessity purely introspective, but he used a standard set of questions and got many persons to answer them: "Think of your breakfast table as you sat down to it this morning. Does the scene come back vividly?

Do you see the whole scene at once? Are the objects distinct? Are the colors bright and lifelike?" Some persons answered, "Entirely so," and others, "Absolutely not." Most people gave intermediate answers which could be arranged in order between the extremes. Those who denied getting any realistic image reported that they remembered the breakfast table without seeming to see it. Though the individual differences in visual imagery were obviously very great, there was no sign of a bimodal distribution (*4*).

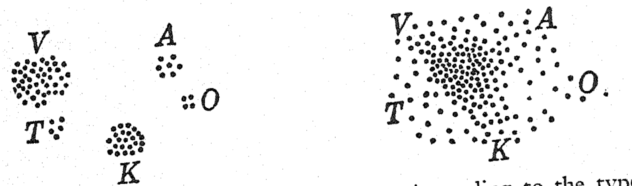


FIG. 10.—Individual differences in imagery. According to the type theory, at the left, each individual has his place in one of the distinct groups, visual, auditory, tactile, kinesthetic, or olfactory. According to the real facts, most individuals have "mixed" imagery and belong in the middle space, leaving only a few to be counted as exclusively visual, or auditory, etc.

Galton's imagery experiment has been repeated many times with the same result. But as some individuals who denied having visual images reported that they could call up sounds or odors or the feel of various objects, a type theory grew up. The population was supposed to fall into several classes according as their imagery was visual, auditory, motor, etc. Every individual, so the theory of certain psychologists supposed, belonged to one or another of these types. One person was said to be "eye-minded," another "ear-minded," still another "muscle-minded," and so on. Further investigation soon showed that a "mixed type" must be admitted to take care of individuals who reported images of two or more senses; and then the mixed type was found to be the most common of all. Very few individuals are limited to images of any one sense. Nearly everyone runs largely to visual images but with occasional images of sound, smell, touch, and bodily movement. The typical individual is the one of

so-called mixed type, while the rare individuals taken to represent the pure visual or auditory type are really *atypical.*

Other type theories have had a similar history. Some exceptional individual is first taken as a type; an opposite type is found and the attempt is made to classify people under these two types. Then intermediate individuals are found and a mixed type is admitted, and the mixed type is presently found to cover the great majority of individuals. The distribution has a single mode instead of the two or more modes assumed by the type theory.

Such experiences have made psychologists skeptical regarding the new type theories that continue to be put out in the study of personality. We must not be dogmatic or close our minds to new evidence, but we have a right to demand good evidence before we will admit the reality of any sharp division into types.

THE CORRELATION OF ABILITIES

We can now take a further and very important step in our study of individual differences. Suppose the same individuals have taken two tests. We wish to know how closely their standings in one test *correspond* with their standings in the other. Does the same individual who scored highest in one score highest in the other also, and is the second-highest individual in one test the second-highest in the other, and so on down the line? If so, there would be (practically) perfect correspondence or agreement between the scores in the two tests. In technical language we should say there was a "perfect positive correlation" between the results of the two tests.

Conceivably, there might be a perfect negative correlation. There might be a law of compensation such that anyone who was poor in one ability was sure to be good in some other line. If compensation were perfect between two tests, the individual scoring highest in one would score lowest in the other, and the order of individuals in one test would be just the opposite of the order in the other test.

Conceivably, again, the two tests might show a zero correlation. The top man in one test might be found anywhere along the range in the other test, and so with the bottom man and with every man. No correspondence, no compensa-

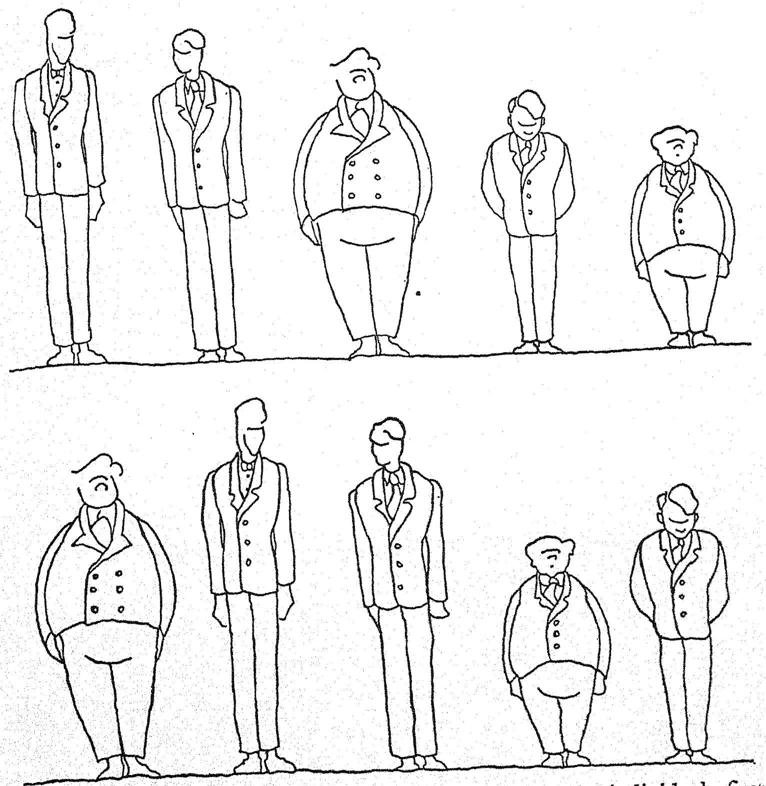


FIG. 11.—Correlation of height and weight. Arrange the individuals first in order of height and then in order of weight, and see how much the positions change. The correlation of these particular individuals, by the rank-difference formula (p. 90), is +.60.

tion, but pure chance such as is approximated by shuffling a deck of cards.

Actually, we never find perfect negative correlation, nor anything like it, between any two tests. Compensation is conspicuous by its absence. We never find perfect positive correlation though we do sometimes get approximations to it. We often find zero or near-zero correlation. Most often,

there seems to be *more or less* correspondence, more or less of positive correlation.

We clearly need some *measure* of correlation, some way of saying *how much* agreement there is between the scores on two tests. Let us adopt the convention of representing perfect positive correlation by the number +1, perfect negative correlation by the number −1, and mere chance relationship by 0. Then we can say that a correlation of +.8 means fairly close positive correspondence, that a correlation of +.3 is low but positive, and that a correlation of −.3 is low and negative.

We appeal to the mathematical statisticians for some method of computing the correlation, and we learn that such methods have been developed for use not only in psychology but in biology, economics and many other fields. Some of the methods have been devised by psychologists, for psychology finds as much use as any science for such statistical techniques.

A few of the methods of measuring correlation will be explained in the supplement to this chapter.

Some sample correlations. Even though one has no occasion to compute correlations, one runs across correlations of .50 or of .80 in general reading and needs a realistic sense of the closeness of correspondence indicated by such numbers. Some idea of the concrete meaning of the correlations can be gained from the following table of values actually obtained. We see that Stature and Arm Spread are correlated to the extent of +.82; here we should expect a close relation, and +.82 is pretty high correlation as things go, though it is by no means perfect. Stature and Weight are less closely correlated ($r = +.59$) as we might expect since a person may change his weight considerably without altering his height. Correlations higher than .85 are seldom obtained except from the use of almost identical tests. Zero values and small positive and negative values are the usual thing where the abilities are obviously quite different in kind such as hand grip, adding, and color naming. A true, significant negative correlation between any two abilities is prac-

tically unknown. The general result is perfectly clear: abilities are positively rather than negatively interrelated, though the relationship is usually moderate rather than close.

A FEW CORRELATIONS
(from various sources)

Anthropometric and strength tests	
Stature and Arm Spread, men	.82
Stature and Weight, men	.59
Stature and Grip, men	.43
Grip, Right Hand vs. Left Hand, men	.74
Grip and Tapping, men	.25
Grip and 100-yard Dash, women	.16
Scholastic tests	
Word Meaning and Paragraph Meaning	.80
Arithmetic: Computation and Reasoning	.70
Punctuation and Spelling	.60
Vocabulary and Spelling	.50
Reading and General Information	.40
High School grades	
Algebra and Geometry	.65
English and French	.50
English and Art	.15
College grades (West Point)	
Two English courses	.77
English and History	.68
English and Physics	.48
English and Mathematics	.49
English and Drawing	.25
Mathematics and Physics	.78
Mathematics and History	.44
Mathematics and Drawing	.48

Uses of the correlation measure. In the construction of tests, great care is necessary to make them as good measuring instruments as possible. There are two qualifications of a good measuring instrument that are specially desired, called by psychologists validity and reliability.

Validity is present when the test measures what it is designed to measure. This point comes out most clearly in tests for vocational guidance or selection. The psychologist prepares a test (or battery of tests) for predicting how well an individual will succeed in a certain occupation. If the test is valid, his predictions based on the test will check with the individual's success or failure in the occupation. Actual success or failure is here the *criterion* against which the test must check; and the test must correlate highly with the criterion in order to possess high validity.

Reliability is present when the test establishes the individual's position definitely in the particular ability tested. If a test is repeated, or if equivalent tests are given to the same individual, and he comes out with the same standing each time, the tests used are reliable. A thoroughly reliable test must have a self-correlation of .90 or above, though many acceptable tests do not fully meet this standard.

Unless a test has fairly good reliability, it is of little use for measuring individual differences; it does not furnish dependable scores to work with. Even if it has good reliability its use may be limited. Such very specific tests as hand grip and reaction time, though highly reliable because giving the same measures in repeated tests of the same individual, are not very valid as indicators of broad individual traits such as strength or speed.

The correlational method in psychology. Alongside of the experimental and developmental methods of investigation, described in the first chapter, the correlational method deserves a place. It is much used today in the hope of discovering the relations between different abilities and the organization of ability in general.

From the correlation of +.70 between computation and arithmetical reasoning we see that the two abilities have much in common, yet not overmuch since this correlation is far from perfect. From the low correlation of +.25 between English and drawing we can infer that these two abilities have a little in common, but only a very little. In general,

correlation indicates how far two abilities are the same and how far they are different.

It is interesting to contrast the experimental and correlational methods. The experimenter may need only a few individuals as subjects, provided they all show the same effects, while a correlational study, based as it is on individual differences, requires a fairly large sample of the population in order to yield a dependable result. The experimenter systematically varies his independent variable, as he calls it (p. 9), and notes the resulting variation in the dependent variable in the subject's performance. The independent variable is cause, the changed performance an effect. The correlationist also deals with two variables, or more, the scores of his subjects in different tests, but his variables are all on a par. We cannot speak of one as the cause and the other the effect. From the correlation of +.70 between computation and arithmetical reasoning we have no right to say that ability to compute is the cause of ability to solve reasoning problems in arithmetic, nor vice versa, but only that the two abilities have much in common. As far as we can tell from a high correlation between two tested abilities, *A* and *B*, *A* may be the cause of *B*, or *B* may be the cause of *A*, or both *A* and *B* may be effects of some third ability which comes into play in both tests. The causal factors may lie out of sight.

ANALYSIS OF ABILITY

The correlational method offers one line of attack on a question which was mentioned near the beginning of the chapter, the question whether one person is abler than another *in general or along certain definite lines*. If a group of individuals were put through many varied tests with the result that certain individuals always came out on top, others always in the middle, others always near the bottom, with few if any individuals shifting around in their standing, the evidence would clearly favor one general ability. Some individuals would simply be abler than others. But we never get that result. The intercorrelations among the tests are

never close to +1.00, except where two tests are practically tests of the same ability, like two tests in adding, or two tests in giving opposites. Two "omnibus tests," also, each consisting of very similar samples of several kinds of tasks, but the same kinds, may show very high correlations. But when each test calls for one definite kind of work, ~~as~~ adding for one, multiplying for one, finding opposites for one, memory for numbers, for words, or for the sense of a passage~~,~~ the correlations run from 0 up to about +.70, with an average correlation of about +.30. The very low correlations indicate that some abilities have very little in common, while the moderately high correlations, +.60 or +.70, point to abilities having much in common. Such are the basic facts to be dealt with in an attempt to analyze human intellectual ability.

Two outmoded theories. These facts are sufficient to disprove two theories of ability that have been suggested in the past. One theory was that every task calls for a separate specific ability, and that individuals differ in any task simply because they possess this specific ability in different degrees. If abilities were as separate as all that, any two tests should give a zero correlation instead of the positive correlation usually found. The other extreme theory held that all ability was a unit, some individuals simply having more, others less, of this general, all-round ability. In that case the correlation between any two tests should be up near +1.00, which is not at all what we find. The facts compel us to seek for some intermediate theory.

General ability plus many very specific abilities. One possibility is to assume both a general ability and a lot of specific abilities. The positive correlations would then be due wholly to the general ability, since the specific ability is assumed to be different for each different task. The individual's performance in any test would depend on two factors, the amount of general ability he possesses and his specific ability to deal with certain materials in a certain way (for example, to deal with numbers by adding them). Some tests, we may assume, depend more on general ability, others

more on specific abilities. Two tests which depend mostly on general ability will show a high correlation, while two tests depending mostly on different specific abilities can have only a low correlation. This theory calls for a graded series of correlations such as we actually obtain. But there is one serious difficulty, now to be presented.

Group factors—abilities of intermediate scope. The just-noticed theory assumed only very narrow specific abilities in addition to one general, all-round ability. The correlations obtained between various tests, however, reveal the existence of abilities that are not broad enough in scope to be called general ability and yet are not narrowly limited to very specific tasks. Clusters of tests are found, the correlations being high between the tests in a cluster, but much lower between tests in one and in another cluster.

For example, tests of college students for speed of addition, subtraction, multiplication and division were found to correlate around +.60 with each other; and tests of opposites, synonyms, reading and vocabulary correlated about +.55; but the correlation between any of these verbal tests with any of the arithmetic tests was only about +.20 (*14*). In another study the subjects were boys ten years old, and the correlations were higher, as is usually the case with young subjects. In a group of verbal tests they were about +.63, and in a group of spatial perception tests they were about +.66, while between verbal and spatial they were about +.43 (*2*). We see evidence here of three rather broad abilities which have come out of other studies as well and which have been called verbal, numerical and spatial abilities. Other data indicate the existence of a mechanical ability and of a musical ability, and there are probably still others which are too broad to be called specific and yet not broad enough to be identified with general ability.

Is there a general ability, too? The facts of correlation of abilities therefore make it necessary to recognize very specific abilities and somewhat broader abilities. Whether it is necessary to assume the existence of general ability also is not certain. The experts in this line of work have devel-

oped very elaborate mathematical methods for treating their data, but are not yet in agreement on this important question (*11*). The notion of general ability is rather attractive. It might amount (a) to *quick learning and good retention* of what has been learned. For suppose that one person is superior in learning and retention: he will accumulate a large stock of knowledge and skill ready for use in tackling any new problem he encounters, and the new learning required by the new problem will also be easy for him. One who learns and retains little is not much helped by his past experience and will make the same mistakes repeatedly. General ability, if there is such a thing, might also consist (b) in quick and accurate *grasping of relationships*, for the intellectual mastery of a problem depends on seeing the essential relations involved. These two views of general ability, put forward respectively by Thorndike (*13*) and Spearman (*10*), may amount to the same thing; for the intellectually useful facts that we learn consist largely of relationships.

How about capacity? Our analysis of ability is not, directly at least, an analysis of capacity, for our tests measure ability and not capacity, and the individual differences revealed are differences in ability. It may be true that individuals differ in their native capacity for music, for mathematics, for artistic or mechanical work, and even for such specific tasks as adding, multiplying, reading, and building up a vocabulary. They may also differ in general intellectual capacity. The best evidence that *individuals do differ in capacity* is obtained by subjecting a group of individuals to intensive training in some special line. Such training, bringing individuals near to the limits of their capacity—in typewriting, in piano or violin playing, in singing, in athletic performances—does not wipe out individual differences. Some individuals advance far beyond the point where others stop.

The differences which we ordinarily find in the adult population are however not due wholly to differing capacity but partly to differences in training and effort. One person specializes in one line, another in another, and thus *ability becomes specialized*. It is significant that the correlation

between tests is higher in children than in adults (5). The child is less specialized in his ability than the adult. The individual's total ability is like a tree which comes up a single sprout and branches out more and more widely. The branching out, in case of human ability, results largely from the various tasks undertaken in school and in the world.

SOME ILLUSTRATIVE TESTS FOR VERBAL, NUMERICAL AND SPATIAL ABILITY

To give the reader an opportunity of seeing and trying tests such as are used in analyzing ability, some test materials have been prepared for this book. The following tests are not standardized, i.e., norms and reliabilities have not been carefully worked out for them, but they have been tried out on fair-sized groups of college students, and the averages and correlations may be of some interest.

Verbal ability is not altogether well named. At least it is not exactly what one might suppose. The tests are not such as would be used in a speech clinic or in a school or college course in "better speech." They do not include tests for clear pronunciation, grammatical correctness, fluency in conversation or good reading technique. The ability tested is not purely "verbal." Rather it is the ability to get ideas from words or into words. Since words stand for things, events, qualities and relations, a vocabulary test is not merely a test of word knowledge, but is to some extent an index of the subject's knowledge of things, etc. An opposites test obviously calls for appreciation of the exact meaning of words. A sentence completion test calls for filling in blanks so as to complete the meaning as well as the grammatical structure of the sentence.

Verbal ability is broad in scope because language is a tool for conveying many varieties of meaning. But not every kind of meaning is readily conveyed in words. Imagine the architect attempting to guide the builders of a house by words alone with no blueprints, or a musical composer trying to get the orchestra to play his symphony by pure verbal

description without use of the symbols of music! Imagine geography with no maps or pictures! Mathematics also, without its numerals and other special symbols, would be almost impossible. Verbal tests therefore cannot compass the whole circuit of human ability.

Numerical ability covers knowledge of numbers and their relations and facility in the fundamental arithmetical operations. Arithmetical problems expressed in words make some demands on verbal ability also, and the more intricate problems call for arithmetical reasoning which is not identical with skillful number work. Numerical ability proper is rather narrow in scope, though very important for some purposes.

Spatial ability is the ability to grasp and use spatial relations. It should include such outdoor skills as finding one's way, keeping one's bearings and remembering locations. It has sometimes been tested with real objects but more often with drawings representing shapes and sizes and especially figures in three dimensions. It is doubtless an important practical ability, though not as yet well mapped out by the psychologist.

Note on taking the tests. In order to compare one's individual score with the averages obtained by the students already tested, one should observe the same time limit, 5 minutes for each one of the six tests.

An *estimate of one's reading vocabulary* can be made by taking the number of known words in the test, multiplying by 200 and then adding 3,000. This estimate would not include any technical words that one may know.

A count of 100 pages from different parts of Webster's Unabridged Dictionary, 1934 edition, indicated that there were about 43,000 words separately entered, when the following classes were omitted: proper names, hyphenated words, phrases, obsolete, rare, dialectical, local, slang and colloquial words, and the technical vocabularies of the various sciences and arts. The present list is a random sample of the remaining words, except that it omits the 3,000 most

commonly printed words according to Thorndike's count (*12*), practically all of which will be familiar to every college student, and except that it includes more and less used words in about equal proportions. The four columns are about equally difficult.

VOCABULARY

Make a short line at the left of each word you know. Be reasonably sure, as the list contains a few fictitious words. Please finish each vertical column before proceeding to the next.

absorbent	accidental	acclimatize	alloy
addiction	afoul	aileron	ammeter
aegis	anatropic	bluing	basilica
agile	arsis	boulevard	braise
ailing	ascension	capstan	buskin
anachronism	beastly	cardinal	candidacy
anaconda	bedspring	casualty	cerement
architrave	cantonment	cellophane	chasm
bloat	caseharden	centerboard	chaotic
bromine	compensatory	concrete	choppy
caliphate	confessor	decant	compendium
cameo	crescendo	discommode	culpability
cantaloup	damask	donatress	curvilinear
clearinghouse	dismoded	effervescent	cytoplasm
commute	enclitic	evensong	disavow
contrabinary	entrench	exhume	elementary
crevasse	erosion	fernery	endogenous
dement	exophoria	genealogist	exality
diameter	flagroot	girth	feint
enhearten	greenback	gnaw	flummery
exquisite	hatchway	grelacious	garland
faience	hepatic	harmonic	gloaming
firth	hunk	hobble	gradation
foliage	interglacial	imbalance	hangar
generative	llama	jasmine	invalidate
ghoulish	matriarch	lithograph	jeweler
grantee	misimprove	patristic	jubilation
haunch	offing	plane	longbow
immanence	pacifiable	plenum	liturgical
insurrectionary	penetrating	polemical	mandatory
malevard	pepsin	postmark	molding

manageable
meringue
okra
plume
poacher
preconception
redden
sabotage
sagamore
scantling
secant
sergeant
singleton
smithereens
sophistry
stickler
traditional
trestle
vibratory
voucher
webfoot

percebate
phosphorescent
pious
plugger
refresh
sacrilege
sconce
seadrome
semifinal
shabby
shoplifter
sludge
solenoid
specific
spikelet
television
timetable
transverse
understate
unfrequented
vilification

privily
prolixity
quartersaw
quandary
random
residency
ruthless
sepal
sepia
shipment
shreddy
snaffle
spirochete
spunky
stenographer
sulphuric
thunderous
ticktack
treamish
twentyfold
uterus

oleander
polka
prate
predictable
reforestation
reprisal
ricer
romaric
scripture
sickroom
signatory
slantwise
souvenir
streamline
stretcher
telepathic
tort
twaddle
ultimate
weir
workbag

SENTENCE COMPLETION

Write one word in each blank space so as to make good sense.

Born in 1863 on a prosperous Indiana farm, Gene Stratton (later Gene Stratton Porter, the .... known author) was the youngest of twelve children. Her father was a preacher as well as a .... He once said he would .... see one of his children the author of a good book than .... on the throne of England.

Gene was distinctly an out-of-door child. As the .... she was the pet of the family; yet she had her little .... to perform, sweeping the walks, ... the chickens and .... the eggs. She had her own little flower ...., caught and fed butterflies, and one spring discovered no .... than 64 bird's .... which she inspected every day.

It was at home that she .... to read and write, but much to her .... she had finally to go to .... and sit indoors all the blessed day. She soon came into .... with the teacher, who had written on the .... the ...., "Little

birds in their nests agree," and was pointing out the good .... set by the birds, when ...., with her intimate knowledge of .... households, interrupted. "Oh, but they .... agree. They fight like anything. They pull feathers and peck at each .... eyes till they are all bloody." She got the .... to be expected. Before long, ..., she settled down to diligent school work and even became an .... in finished recitation. When her .... moved from the farm to a small .... she continued her .... up through .... school. She did not go to .... and always insisted that she had derived more .... from studying what she liked in her own way.

An important event in her high school days was the .... of an essay before the school assembly. The topic, "Mathematical Law," had been .... to her, but as ...., of all the school subjects, was .... to her, she delayed writing the ...., and at the last moment determined to choose her own .... and write an appreciation of her favorite piece of fiction, a .... which she had loved since childhood. "At midnight I laid down the pencil and .... what I had written. I could make no .... I had given my heart's blood. It came in a tide and to touch it were sacrilege." When her .... came, next day at school, she announced that as she knew .... on the topic assigned her, she had .... another topic, and .... to read, fully .... to be halted by a sharp reprimand. Instead, she found that her .... was with her, ... and .... alike. Indeed her success was so .... as to fan into a .... her long-cherished ambition to be a .... When her ardor was brought to a temporary .... by the danger of school ...., her secret file contained two novels and two volumes of verse. It was some years, however, before she .... to submit any of her writings for ....

NUMBER SERIES

Each horizontal line of numbers follows a different rule. In this sample line

4	8	5	10	7	—	11

the rule is to multiply by 2 and subtract 3, alternately, so that the number 14 belongs in the blank space. Some of the rules are simpler than this. In each line discover the rule and fill in the blank.

2	4	6	8	10	—	14
10	9	8	7	6	—	4
5	7	9	11	13	—	17
78	67	56	45	34	—	12
1	2	4	8	16	—	64
5	6	8	9	11	—	14
60	57	52	49	44	—	36
3	5	10	12	24	—	52
7	4	12	9	27	—	72
3	12	10	19	17	—	24
10	11	13	16	20	—	31
0	2	6	12	20	—	42
36	35	33	30	26	—	15
100	90	81	73	66	—	55
20	21	19	22	18	—	17
25	20	15	10	5	—	—5
16	8	4	2	1	—	¼
10,000	1,000	100	10	1	—	.01
1	4	9	16	25	—	49
0	1	8	27	64	—	216

NUMBER QUESTIONS

Write ¾ as a decimal fraction.
Divide 7 by 3 and add 2 to the quotient.
Divide: 17)51884.
Add ⅙ and ⅛.
$(3+4+5)/3=?$
$10-(7-3)=?$
$20-3(8+2)+15=?$
$(1+2)^2=?$
If $x=5$, how much is $2x^2-10$?
If $x=5$ and $y=7$, how much is $(x+y)(x-y)$?
If $x=5$ and $y=7$, how much is $(x-5)(9x+34y)$?
If $x=y$, how much is $\dfrac{3x-y}{2x-y}$?
How much is 1/12 of 9 dozen eggs?
How much is 1 yard, 2 feet *less* 4 feet, 7 inches?

If I read 36 pages per hour, how many seconds does it take me to read a page?

A weighs 135 lbs., *B* 148 lbs., and *C* 167 lbs. What is their average weight?

4 men earn $48.00 in 3 days. At that rate, how much do 5 men earn in 2 days?

Find 2% of a million.

If I drink 3 pints of water a day, how many gallons do I drink in a week?

The annual death rate in a certain city of 250,000 is 12 per thousand. How many people die there in the average month?

SPACE QUESTIONS

Arrange these countries in order from North to South:

England, Spain, Sweden, Egypt

Arrange these towns in order from East to West:

Chicago, Denver, Boston, Detroit

At what time between half-past-five and half-past-six are the hour and minute hands exactly opposite?

How large is the angle between Northeast and Northwest?

A boy is standing on his head with his right hand toward the West. Which way is he facing?

If I go North one mile and then East one mile, in what direction am I from my starting point?

If I go Southeast one mile and then Southwest one mile, in what direction am I from my starting point?

If I go East one mile, Southwest one mile, and finally Northwest one mile, in what direction am I then from my starting point?

Cross out the name of *one* object that does not belong, spatially, in the same class as the rest:

ball, pillar, sheet, box

The same here:

page, map, ceiling, barrel

The same here:

ellipse, cube, sphere, circle

The same here:

surface, border, ring, loop

Two towns are on the same bank of a river, but the straight road between them crosses the river twice. Show by a diagram how this can be.

A steamboat is going North while a West wind is blowing. Show by a diagram the streak of smoke from the funnel.

A ball is thrown obliquely against a wall. Show by a diagram the angle of rebound.

What point on a rolling hoop is moving forward most rapidly at any moment?

MATCHING FORMS

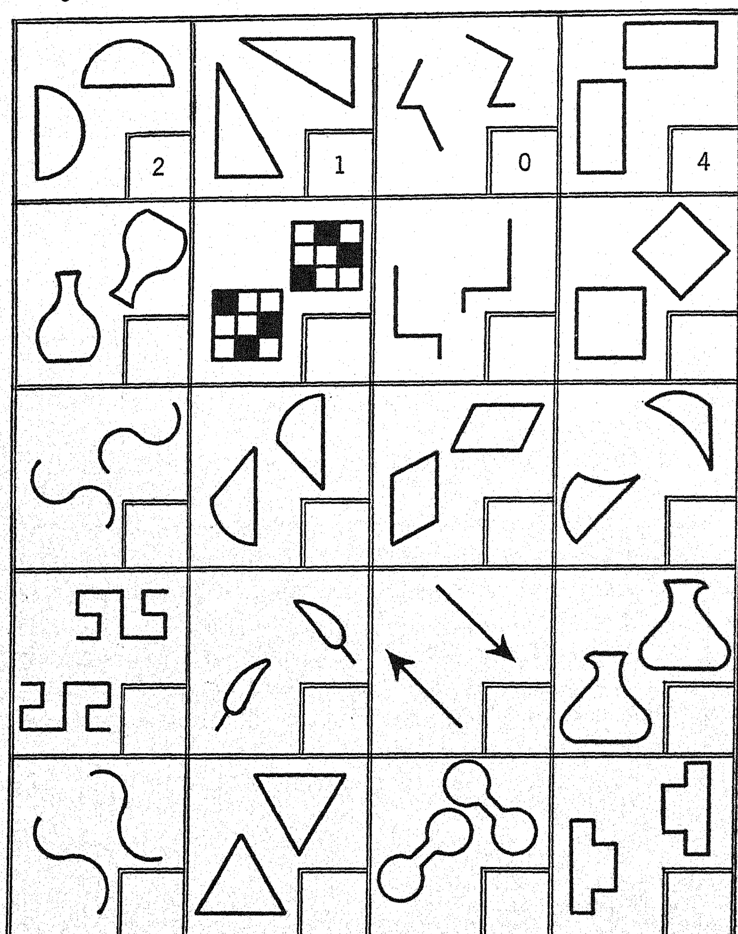
Imagine the upper figure in each box to be a flat block, and the lower figure a hole into which the block is to be fitted. In how many ways will it fit? Write the answer in the small square.

The semicircle in the first box can be slid around flat and inserted. Then it can be picked up and turned over (like a penny, heads up to tails up) and inserted again. The answer is 2.

The triangle cannot be fitted by sliding but must be turned over. Answer: 1.

The jagged line in the third box will not fit in any position.

The rectangle can be fitted in two positions (end for end) without turning over, and then turned over and fitted twice more.



RESULTS OBTAINED WITH THESE SIX TESTS

The six tests were given to students in elementary psychology classes in the following colleges in New York City: College of the City of New York, Brooklyn College, Hunter College, Barnard College, and Columbia College and Extension classes. The total number of subjects was 400, being 259 women and 141 men. The time limit for each single test was five minutes. In scoring the Vocabulary Test, a penalty of 10 words was deducted for each fictitious word marked as known to the subject. The Averages and *SD*'s were as follows:

	MEN		WOMEN	
	Average	*SD*	*Average*	*SD*
Vocabulary	141.85	25.04	138.74	22.32
Sentence Completion	26.02	7.86	30.36	8.28
Number Series	15.08	4.30	13.93	4.64
Number Questions	11.54	3.14	10.04	3.13
Space Questions	9.26	2.51	8.05	2.53
Forms	8.82	4.45	6.86	3.87

The fact that the average is higher for the men in some tests, and for the women in one test, is not to be taken too seriously. The *SD* values show that each sex scattered widely, and that the distributions for the two sexes must have overlapped, as in fact they are seen to do in Fig. 12, which shows the results from the test that showed the greatest sex difference. That is, the individuals within each sex differ among themselves so much as to make the difference between the sexes of small consequence. Such is the result in practically every instance of sex differences in mental ability.

The total reading vocabulary, estimated as explained on p. 77, averages about 31,000 common words for this class of individuals.

Correlations between these tests. The expectation was that higher correlations would be found between the two verbal tests, between the two numerical tests, and between the two

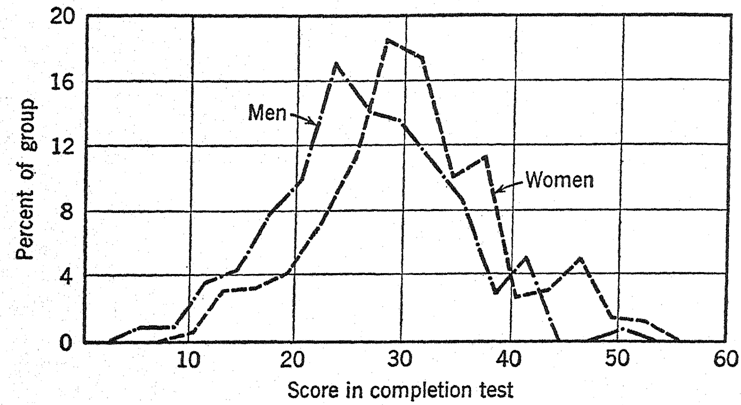


FIG. 12.—A sex difference.

spatial tests, than between the different kinds of tests. The correlations found confirm this expectation to a moderate degree.

Correlation between

Vocabulary and Sentence Completion	+.46
Number Series and Number Questions	+.48
Forms and Space Questions	+.33
Verbal and Numerical tests	+.17
Verbal and Spatial tests	+.26
Numerical and Spatial tests	+.35

The tests, with five-minute time limit, were too brief to be very reliable. With longer tests of the same kind the correlations would probably be somewhat higher. The two spatial tests turn out not to have much in common, dealing as they do with very different sorts of space problems.

Leaving the spatial tests aside we find our expectation confirmed by the low correlation of +.17 between verbal and numerical, compared with +.46 between the two verbal and +.48 between the two numerical tests.

The highest correlation obtained in this study was that between Vocabulary and Sentence Completion, with the women students alone. It was +.53, and it is shown graphically in Fig. 13.

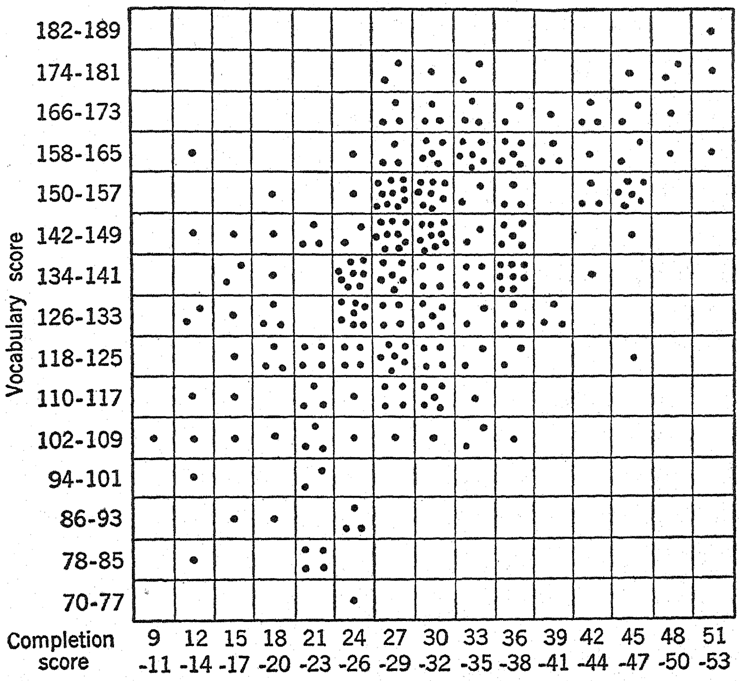


FIG. 13.—A correlation chart. Each individual is represented by a dot, so placed as to show her score both in the Completion test and in Vocabulary. The higher the correlation, the more nearly all the dots would lie in a diagonal extending from the lower left-hand corner to the upper right-hand corner. The dots here streak in that direction but the correlation is visibly far from perfect. It measures +.53.

STATISTICAL SUPPLEMENT: MEASURES OF DISTRIBUTION AND CORRELATION

Average and standard deviation. There are other measures of the center of the distribution and of the scatter, but the most used are the Average and the Standard Deviation.

Everyone knows one way of computing the *average:* Add up all the scores and divide by their number. The average of 4, 5, 6, and 9 is

$$(4+5+6+9)\div 4=6$$

A good measure of scatter should tell how far the individuals in general deviate from the average. We may there-

fore find the distance of each individual score from the average, add up all these deviations and divide by the number of individuals, so obtaining the "average deviation." The best measure of scatter, however, is the *standard deviation,* or *SD,* obtained by squaring each individual deviation, then adding them, dividing by the number of cases and finally extracting the square root.

The deviations of the four numbers given above from their average are -2, -1, 0, and $+3$. Adding these, without regard to their signs, and dividing by their number, we obtain the average deviation $= 1.5$. Squaring these same 4 deviations, adding, dividing by 4 and extracting the square root, we have $SD = \sqrt{3.5} = 1.87$.

One use of these statistical measures can be seen by attempting to answer the question, how to report *the individual's standing in the group.* His raw score, like any isolated measure, tells nothing at all. Knowing the group average, we can say that the individual stands above or below the average. We can state his deviation from the average. But the raw deviation means little; we should be asked how much other individuals deviate. By use of a measure of scatter we can make a much more exact statement. We can convert the raw score into a "standard score," or "*SD* score" as we will call it. The *SD score* is plus or minus according as the raw score is above or below the average, and it is *so many times the SD above or below the average.* It is obtained by dividing the deviation of the raw score by the *SD.*

For example, if the four numbers given above are the raw scores, the *SD* scores are obtained by dividing the deviation -2 by the *SD* 1.87, and so on. The *SD* scores so obtained are -1.07, $-.53$, 0, and $+1.60$. (Of course the *SD* scores will usually not "come out even," and they can be carried to as many places of decimals as the data warrant—usually only one or two.)

The *SD* score tells where the individual stands in relation to the group as a whole. The *SD* scores of the same individual in two tests show how his standing in the one com-

pares with his standing in the other. The raw scores in two tests are not directly comparable, in general, while the *SD* scores are always comparable.

Thus, if an individual makes a score of 14 examples in a test for speed of adding, and a score of 9 examples in a test for speed of dividing, these raw scores do not indicate that he did better in adding, necessarily; for the division examples may have been harder. But if each of these raw scores, converted into an *SD* score, comes out as +.67. the conclusion is that the individual did just as well in one test as in the other, in relation to the group as a whole.

If the distribution of scores is about normal (see p. 64), each *SD* score means also that the individual surpassed a certain percent of the group. Thus:

If the *SD* score is	+2.5,	it surpasses about	99%	of the group
" " " " "	+2.0,	" " "	98%	" " "
" " " " "	+1.5,	" " "	93%	" " "
" " " " "	+1.0,	" " "	84%	" " "
" " " " "	+.5,	" " "	69%	" " "
" " " " "	0,	" " "	50%	" " "
" " " " "	−.5,	" " "	31%	" " "
" " " " "	−1.0,	" " "	16%	" " "
" " " " "	−1.5,	" " "	7%	" " "
" " " " "	−2.0,	" " "	2%	" " "
" " " " "	−2.5,	" " "	1%	" " "

How to measure correlation. There are several formulas, all based on the same general principle. For perfect correlation, each individual must have the same standing in both tests—the same, that is, in relation to the group as a whole. When the group is small, the simplest method is to rank the individuals in order from best to worst, in each test. Each individual then has two rank numbers, indicating his standing in the two tests. If every individual's two rank numbers are the same, the correlation is perfect; if they differ a good deal the correlation is low. Find the difference between an individual's two rank numbers and denote this difference by the letter *D*. Square *D*. Do the same for each individual. Find the sum of these squares and use the following formula:

$$\text{Rho} = 1 - \frac{6 \text{ Sum } D^2}{n(n^2 - 1)}$$

Here n is the number of individuals. "Rho" is a measure of correlation, known as the *rank-difference* measure. One can easily see that Rho = 1 for perfect correlation, for then each and every D is zero. (It also works out mathematically that Rho = −1 for perfect negative correlation, and that Rho = 0 for a purely chance relationship between the two sets of scores.)

As an example of this method of computing correlation, take the scores of 10 individuals who have taken an addition test and a division test, and rank the scores in order, as is done below.

COMPUTATION OF RHO BY RANK-DIFFERENCES

	Addition		*Division*			
Individual	*Raw Score*	*Rank Number*	*Raw Score*	*Rank Number*	D	D^2
A	18	1	9	2	1	1
B	14	2	11	1	1	1
C	12	3	8	3	0	0
D	11	4	4	8	4	16
E	10	5.5	5	6.5	1	1
F	10	5.5	7	4	1.5	2.25
G	8	7	3	9	2	4
H	7	8	6	5	3	9
I	6	9	5	6.5	2.5	6.25
J	4	10	2	10	0	0

Sum $D^2 = 40.50$

6 Sum $D^2 = 243$

$n = 10$

$n^2 - 1 = 99$

$$\text{Rho} = 1 - \frac{6 \text{ Sum } D^2}{n(n^2 - 1)}$$

$$= 1 - \frac{243}{10 \times 99}$$

$$= 1 - .25$$

$$= +.75$$

An important technical point comes out in the rank numbers for Addition. Individuals *E* and *F* are tied for 5th place, and we might think the thing to do was to give them both a rank number of 5 and proceed to rank *G* 6, *H* 7 and so on. Then we should have no rank number 10 and our formula would be spoiled. It is fully as logical to say that *E* and *F* are tied for 6th place as well as for 5th and therefore to give both a rank of 5.5. In the same way, if three individuals were tied, say, for places 7, 8 and 9, we should rank all of them 8.

With a large number of individuals tested, the rank-difference formula becomes unwieldy and inaccurate, and the *product-moment* measure is used. The principle can be understood by reference to the *SD* scores. Let each individual's standing in each test be expressed as an *SD* score. For perfect correlation each individual's two *SD* scores must be identical, and the more they differ the more the correlation is lowered. Therefore find for each individual the difference between his two *SD* scores (taking account of their signs) and denote this difference by d. Square each d, take the sum of the squares, and use the following formula:

$$r = 1 - \frac{\text{Sum } d^2}{2n}$$

Here n is the number of individuals, and r is the product-moment measure of correlation. In perfect positive correlation, every d is zero and thus $r = 1$.

This product-moment measure is usually computed in a different way, without the labor of computing the *SD* scores. Work directly with the deviations of the raw scores. Multiply together each individual's two deviations (taking account of their signs), thus obtaining a deviation-product for each individual. Sum these products (still keeping account of signs) and use the following formula:

$$r = \frac{\text{Sum of the deviation-products}}{n \times \text{product of the two } SD\text{'s}}$$

In more compact symbols this takes the common form:

$$r = \frac{\text{Sum } xy}{n\ \sigma_x\ \sigma_y}$$

Here x and y are each individual's deviations from the two test averages, and σ_x and σ_y are the *SD*'s of the two tests.

The two formulas for r, though quite different in appearance, are mathematically equivalent and should give the same result aside from errors of approximation. The value of Rho need not be quite the same, and in fact is usually .01 or .02 smaller than the value of r from the same data.

The computation of r, by both methods, will now be shown with the same scores as were used before in computing Rho.

SCORES IN ADDITION

Individual	*Raw Score*	*Deviation*	*Deviation Squared*	*SD Score*
A	18	+8	64	+2.1
B	14	+4	16	+1.0
C	12	+2	4	+.5
D	11	+1	1	+.3
E	10	0	0	0
F	10	0	0	0
G	8	−2	4	−.5
H	7	−3	9	−.8
I	6	−4	16	−1.0
J	4	−6	36	−1.5

$n = 10$ Sum $= 100$ Sum $= 150$

Average $= 10$ $SD^2 = 150/10$

$= 15.0$

$SD = 3.9$

SCORES IN DIVISION

Individual	*Raw Score*	*Deviation*	*Deviation Squared*	*SD Score*
A	9	+3	9	+1.2
B	11	+5	25	+1.9
C	8	+2	4	+.8
D	4	−2	4	−.8
E	5	−1	1	−.4
F	7	+1	1	+.4
G	3	−3	9	−1.2
H	6	0	0	0
I	5	−1	1	−.4
J	2	−4	16	−1.5

$n = 10$ Sum $= 60$ Sum $= 70$

Average $= 6.0$ $SD^2 = 70/10$

$\doteq 7.0$

$SD = 2.6$

COMPUTATION OF r BY SD SCORE DIFFERENCES

Individual	*SD Scores in Addition*	*SD Scores in Division*	*d*	d^2
A	+2.1	+1.2	.9	.81
B	+1.0	+1.9	.9	.81
C	+.5	+.8	.3	.09
D	+.3	−.8	1.1	1.21
E	0	−.4	.4	.16
F	0	+.4	.4	.16
G	−.5	−1.2	.7	.49
H	−.8	0	.8	.64
I	−1.0	−.4	.6	.36
J	−1.5	−1.5	0	0

$n = 10$ Sum $d^2 = 4.73$

$$r = 1 - \frac{\text{Sum } d^2}{2n} = 1 - \frac{4.73}{20}$$

$$= 1 - .24$$

$$= +.76$$

COMPUTATION OF r BY DEVIATION-PRODUCTS

Individual	*Deviations in* Addition	*Deviations in* Division	*Deviation-product*
A	+8	+3	+24
B	+4	+5	+20
C	+2	+2	+4
D	+1	−2	−2
E	0	−1	0
F	0	+1	0
G	−2	−3	+6
H	−3	0	0
I	−4	−1	+4
J	−6	−4	+24
		Sum of deviation-products =	+80

$$r = \frac{\text{Sum of deviation-products}}{n \text{ product of the two } SD\text{'s}}$$

$$= \frac{+80}{10 \times 3.9 \times 2.6}$$

$$= \frac{+80}{101.4}$$

$$= +.79$$

(The values of r obtained by the two formulas differ simply because the computation was carried to only one decimal place. Carrying the *SD* and the *SD* scores to two decimal places gives us $r = +.78$ in both cases.)

Computation of correlation by way of the *SD* scores involves some work that is superfluous unless one is interested in the individuals and wishes to know how they stand in the group and how they compare in consistency. The larger the d (or the D in the rank-difference method) the less the individual's consistency. Individual *D* shows the least, individuals *C* and *J* the most consistency in these data.

For working with larger tables of data, more practical

methods are available than any of those which have been shown here (*6*, 7).

Summary of the chapter. Ability denotes what the individual can do, capacity denotes what he can learn to do. Our tests, showing what he can do, are tests of ability and not directly of capacity. Every test shows individuals to differ in ability. They scatter over a certain range of ability, clustering about a single mode rather than about two or more modes. Evidence for distinct types of people, in mental imagery or in any ability, is entirely unconvincing.

Ability as it appears in action, i.e., in tests, is not one undivided total power nor is it split into many separate abilities. Very specific abilities, limited to one narrow task, do exist, but so do abilities of broader scope, such as what are called verbal, numerical and spatial abilities. There may also be such a thing as general, all-round ability.

These results are obtained by use of statistical methods for measuring the distribution of any ability and the correlation between abilities. Some of these statistical methods are briefly explained in a supplement to the chapter.

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Chapter IV

Intelligence

IN TURNING from a chapter on ability to one on intelligence, the reader will query what the difference can be. Is intelligence a particular kind of ability, or the sum total of all abilities, or is it perhaps ability put to practical use? The word comes from common speech and is not a technical term invented by the psychologist. The psychologist has come into the picture because of the obvious fact that individuals differ in intelligence. He is needed to provide means of measuring intelligence, to seek out the causes and effects of these individual differences, and to give advice on the practical problems involved.

With regard to definition, one thing is clear at the outset. "Intelligence" is one of those nouns that are properly verbs or adverbs. A person is intelligent if he acts intelligently, stupid if he acts stupidly. He is intelligent when he handles a situation intelligently, stupid when he attacks a problem stupidly.

Intelligence is contrasted with brute force. When a door sticks, one reaction is to push harder and harder till something gives way; another is to discover why it sticks and then to remove or avoid the obstruction. The intelligent act depends on understanding the situation.

As a word, *intelligence* is closely related to *intellect*, which is a comprehensive term for observing, understanding, thinking, remembering and all ways of knowing and of gaining knowledge. Intellectual activity yields knowledge of a situation. Intelligent activity does this and something more. It is *useful*, it helps in solving a problem and reaching a goal.

Counting, for example, is an intellectual activity and yields knowledge, but whether this knowledge is useful or not depends on the matter in hand. Counting the chairs in your room and the guests you expect is an intelligent way of making sure you have enough chairs, but counting the letters on the page is scarcely an intelligent start toward learning a lesson. In common speech, then, intelligence means *intellect put to use*. It is the application of intellectual abilities in handling a situation or accomplishing any task. This will serve as a preliminary definition.

Feeblemindedness. Long before psychologists made any attempt to define and measure intelligence—indeed, long before there were any psychologists in the modern sense—it was well known that some individuals in any large community were deficient in intelligence. They were too stupid to manage their own lives. Those showing the greatest deficiency were called idiots, those somewhat less defective were the imbeciles. The least defective group, the morons, far outnumber the idiots and imbeciles.

Idiots do not even avoid the common dangers of life, but will put their hands into fire, walk heedlessly into deep water, or remain in the way of an automobile. They cannot learn to wash and dress themselves, and the most deficient do not learn to eat, drink and care for their bodily needs. They do not talk beyond a few monosyllables.

Imbeciles do learn to avoid the common dangers of life. They talk a little but cannot learn to read. Nor can they do much useful work; the lowest of them are incapable of any work, those somewhat higher in the scale learn to perform a few acts under supervision, and those near the upper limit of the imbecile class learn to dress, wash and feed themselves, but cannot be trusted to perform any but the simplest and briefest tasks without constant supervision.

Morons can be taught to do simple routine work without constant supervision. In an institution they make the beds and run errands, and some "high-grade morons" become skillful in taking care of animals, in tending babies, in carpenter work, or in operating a lathe or sewing machine.

Progressive institutions for the feebleminded have had considerable success in training high-grade morons of stable character for remunerative employment in the general community; but they still need general supervision by someone who understands their limitations and has their welfare at heart. Without such assistance, the morons are likely to spend their money foolishly and to make poor use of their leisure time; the girls are easily led into prostitution and the boys into thievery. In general morons do not handle a novel situation or complicated problem with much success.

The legal definition of feebleminded persons or morons adopted in Great Britain after a careful survey is worth quoting (*29*). The feebleminded are:

> Persons in whose case there exists mental defectiveness which, though not amounting to imbecility, is yet so pronounced that they require care, supervision, and control for their own protection or for the protection of others, or, in the case of children, that they appear to be permanently incapable by reason of such defectiveness of receiving proper benefit from the instruction in ordinary schools.

The feebleminded child, then, does not cope successfully with the intellectual tasks of the school; the feebleminded adult cannot cope with the practical problems of life in the social environment. The two parts of the definition seem rather different in their implications, but are easily reconciled. The school child continually has something new to learn, and he shows intelligence by successfully meeting new tasks. The adult in the community, though his life may become very largely a matter of routine, encounters novel situations from time to time and at such times mental deficiency makes itself painfully manifest. Both in the child and in the adult intelligence is demanded for meeting novel situations.

Early in the last century, when scientific interest was first attracted to the feebleminded, some hope was entertained that they could be brought up to normal intelligence by suitable education. This hope has never been realized, but

the moron, at least, can be taught much that will help him in life, provided his limitations are recognized. Idiots and imbeciles would often have been normal except for damage to the brain by birth injury, encephalitis, etc. Morons are usually not pathological cases; they are simply very dull individuals, falling near the low end of the distribution curve for intelligence. There is a continuous gradation from the morons through a large borderline group into the great mass of the normal population.

INTELLIGENCE TESTING

Psychological work on intelligence started from the practical side. About the year 1900 the school authorities of the city of Paris, disturbed by the large number of children who were backward in their school work—a condition present in practically every community—wished to find out whether this backwardness was due to inattention and mischievousness, as the teachers were apt to assume, or to insufficient capacity. Here were children who were not feebleminded in the full sense of the word, but who did not succeed in mastering the school subjects. Now if a child is not feebleminded he must be normal in intelligence—so the older theory ran—and if he is normal he can master ordinary school work. The alternative possibility, that ability shades off by imperceptible degrees from high to average and from average to low, was not so familiar in 1900 as it is today.

Alfred Binet, one of the leading psychologists of that time, undertook to find the answer to these important questions. He saw that some means must be found to *measure* intelligence. After experimenting with various possible methods he came to the conclusion that no single performance would make a fair test. The child must be given plenty of chances to utilize any special knowledge or ability he might possess. Accordingly the Binet-Simon scale, prepared by Binet and a collaborator, was an assembly of many little tests (*1*). Tests of graded difficulty were obviously needed; and here Binet had the brilliant idea of utilizing the known fact that

children increase in ability as they grow up. His easiest tests were just within the reach of three-year-olds, those next in order were beyond the average three-year-old but within the power of the four-year-olds, and so on up the scale. Since he could not tell by inspection the exact difficulty of the test items, he tried them on children of different ages and modified them till each item was fitted to some particular age level. Years of experimentation and several revisions were necessary before the Binet tests were shaped into a fairly accurate measuring instrument, and Binet himself died, in 1911, before his task was fully completed. But his tests, quickly found useful by the psychologists of various countries, have been adapted, revised again and again, and extended in scope down to the first-year level and up to the level of superior adults.

In one recent revision (27), the investigators first collected thousands of possible test items, and tried out the most promising on 1,500 subjects ranging in age from the pre-school to the adult level. Any item that proved uninteresting to the children or adults for whom it was intended had to be rejected, since good motivation of the subject is required for accurate measurement of ability. If the answers to an item were such that different examiners disagreed on the scoring, the rule for scoring had to be carefully formulated or the item rejected in the interests of *reliability*. (The primary criterion of *validity* still remains the same as Binet used, namely, that intelligence increases as the child grows up. If a given item is passed by a few of the 7-year children, by about half of the 8-year and by nearly all the 9-year children, that item is a good one for indicating mental growth at about the 8-year level.) From the results obtained with the 1,500 children the test items were weeded out and 400 items kept for a second trial. These items were next tried on 3,000 subjects ranging from 2 to 18 years in age, all white Americans, native-born though of varied ancestry. So as to represent the country at large, the subjects were obtained in 11 states, from Vermont and Virginia to California. Urban and rural districts, and the various occupational groups (professional, business, clerical, agricultural, skilled and unskilled labor)

were sampled in such proportions as fairly to represent the white population of the country. From the results of this second tryout, two batteries of 129 items each were selected, each battery being so arranged and standardized as to give a correct measure of Mental Age according to the definition given below (p. 111). The object of this elaborate investigation was to increase the reliability and validity of the Mental Age measure. Even now we cannot hope that perfection has been attained. Another painstaking revision (*17*) has followed a somewhat different plan, and the merits of these two new revisions of the Binet tests will be determined by the further experience of hundreds of expert psychological examiners.

Materials used in intelligence tests. In order to avoid vague and mystical interpretations of the results obtained from intelligence tests, we need to clarify our definition of intelligence by noticing (a) how it is tested and (b) what uses are successfully made of the results.

(a) From the methods used in testing intelligence we can judge what the intelligence must be that is tested. It makes little difference how the psychologist defines intelligence in the abstract; when he attempts to measure it he has to adopt some method and use certain materials, and what he measures is the subject's performance in the tasks actually used. "What demands do these tasks make on the subject?" That is the first question to ask in getting a proper conception of tested intelligence. Like other scientific terms, intelligence must be defined in accordance with the operations employed in measuring it. The test materials and procedure, with the subject's responses, make up the testing operation and when carefully studied may provide an *operational definition* of intelligence.

(b) We need also a *correlational definition* such as will show the uses of tested intelligence in practical and social life. The tests reveal large individual differences and we ask whether these differences are of any importance. Until we know the role intelligence plays in life we scarcely have a

complete definition. But first we need a concrete notion of the tests themselves.

Binet test items. Some idea of the varied material used by Binet and his successors is given by the sample items below. Usually 6 items are used at each age level. The following samples are taken from several sources.

4-month level: sitting with back supported for 30 seconds.

6-month level: reaching for a small bright object dangled before the child within his reach.

12-month level: imitating the examiner who shakes a rattle or rings a small bell.

2-year level: removing the paper wrapping from a piece of candy before putting the candy in the mouth.

2½-year level: naming 4 out of 5 familiar objects presented in the form of toys.

3-year level: stringing beads, at least 4 beads to be strung within a time limit of 2 minutes.

6-year level: finding omissions in pictures of faces, from which the nose, or one eye, etc., is left out. Four such pictures are shown and 3 correct responses are required to pass the test.

9-year level: telling how wood and coal are alike and also how they are different. Both likeness and difference must be given for each of 4 such pairs named by the examiner.

12-year level: correct interpretation of a picture showing an incident.

14-year level: explaining the physical absurdity involved in a certain picture.

Adult, 4 levels: free definitions of 20, 23, 26 and 30 words from a graded list of 45 words.

The question may be raised, "Why such arbitrary standards—4 out of 5 correct answers required in one test, 4 out of 4 in another, 20 out of 45 words to be defined?" The answer is that the standards are really not arbitrary; they have been carefully adjusted to correspond to the success of average children at the different ages.

Special training, as well as tact, is necessary for the psychological examiner. Unless he can enlist the subject's interest and co-operation, while still giving the tests in the stand-

FIG. 14.—(From Goodenough, *9*.) Children's drawings of a man.

A. Score 0, M.A. (mental age), less than 3 years.

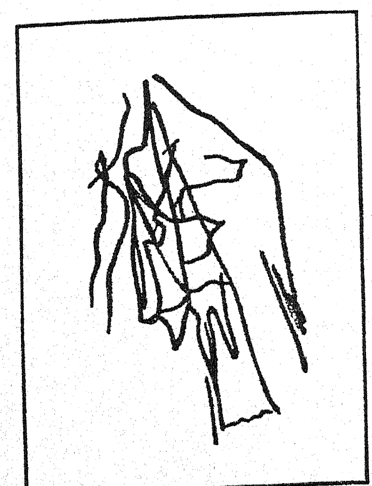
B. Score 4 points, for head, legs, arms, eyes; M.A., 4 years.

C. Score 8 points, for head, legs, trunk, trunk longer than wide, eyes, pupils of eyes, mouth, forehead; M.A., 5 years.

D. Score 14 points, for head, legs, arms, trunk, trunk longer than wide, arms and legs attached to trunk, eyes, nose, mouth, ears, hands, legs in fair proportion to trunk, some clothing, firm and well-controlled lines; M.A., 6 years, 6 months.

E. Score 26 points, including most of those mentioned above, and in addition: shoulders, neck, neck continuous with head, hair, clothing non-transparent, fingers, thumbs, arms and legs shown in two dimensions, heels, head in fair proportion, eyebrow; M.A., 9 years, 6 months.

F. Score 44 points, including most of those mentioned above, and in addition: lips, nostrils, elbow, knee, projecting chin, profile, eye detail (4 points), ears in correct position and proportion, arms attached at right point, hair non-transparent and well shown, good proportion of head, arms, legs and feet, good lines and motor control (3 points), costume complete without incongruities (5 points): M.A., 13 years or over.



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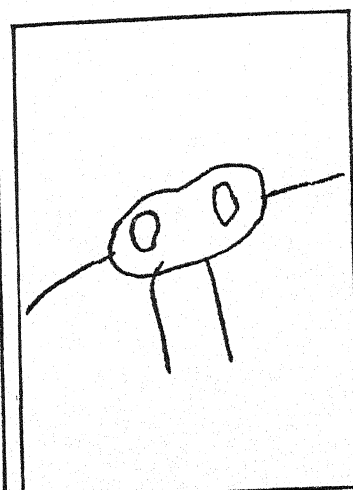

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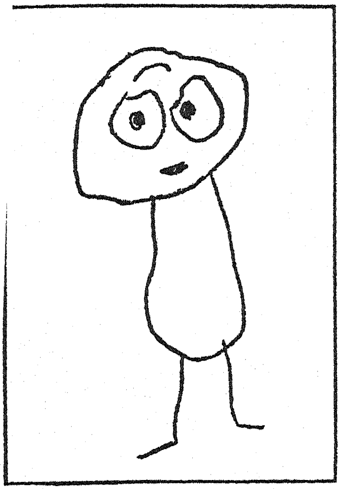

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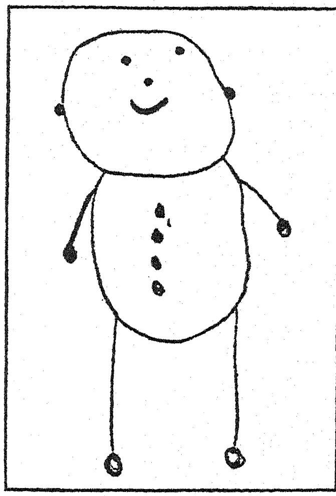

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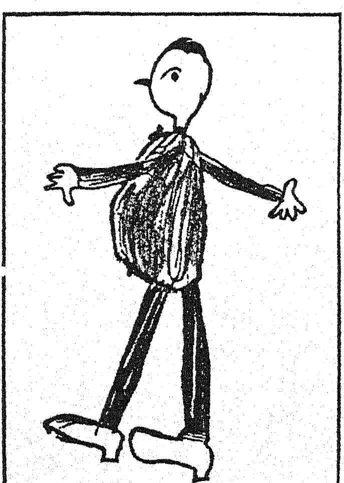

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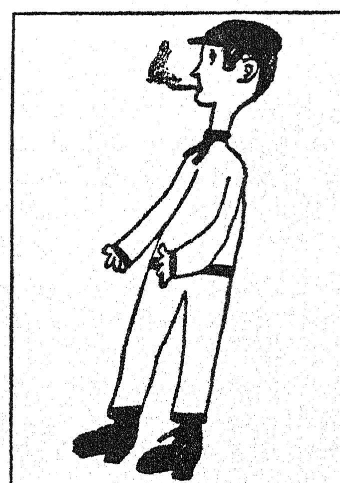

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ard manner and not helping the subject over the difficult places, his measurements may be absurdly inaccurate. The Binet test system is one of the psychologist's instruments of precision, and the novice must learn the requisite technique from the expert.

In order to broaden our acquaintance with test materials we may glance at types of intelligence tests which differ somewhat from those of Binet.

Performance tests, as compared with the Binet type, make little use of oral question and answer, and more use of concrete materials. They are especially useful when the subject is not well acquainted with the language used in the tests; and some persons, even without any language handicap, do better when dealing with concrete objects than when answering questions. The "form board" is an example of a performance test. Blocks of different shapes are to be fitted into corresponding holes in a board; the time is taken and the errors counted. An error is an attempt to insert a block into a hole of different shape. To the average adult this is too simple a task to serve as a test of intelligence, but the young child finds it difficult, and the adult of low intelligence goes at it in the same haphazard way as the young child, trying to force the square block into the round hole. He does not clearly grasp the principle of matching blocks and holes according to their shape.

A "man-drawing test" does good service at ages four to ten (9). The child is simply asked to "make a man, the best man you can make," with pencil on paper. The drawing is scored not for aesthetic value but for completeness and coherence. The advance with age consists partly in including more items in the picture, partly in placing the items in better relation to each other (attaching the arms to the trunk rather than to the head), and partly in representing the man as he could be seen at one time (not putting two eyes in a profile face, nor showing the legs through the trousers).

Still another performance test presents a maze, through which the shortest path must be traced with a pencil. Success demands looking ahead and avoiding blind, impulsive

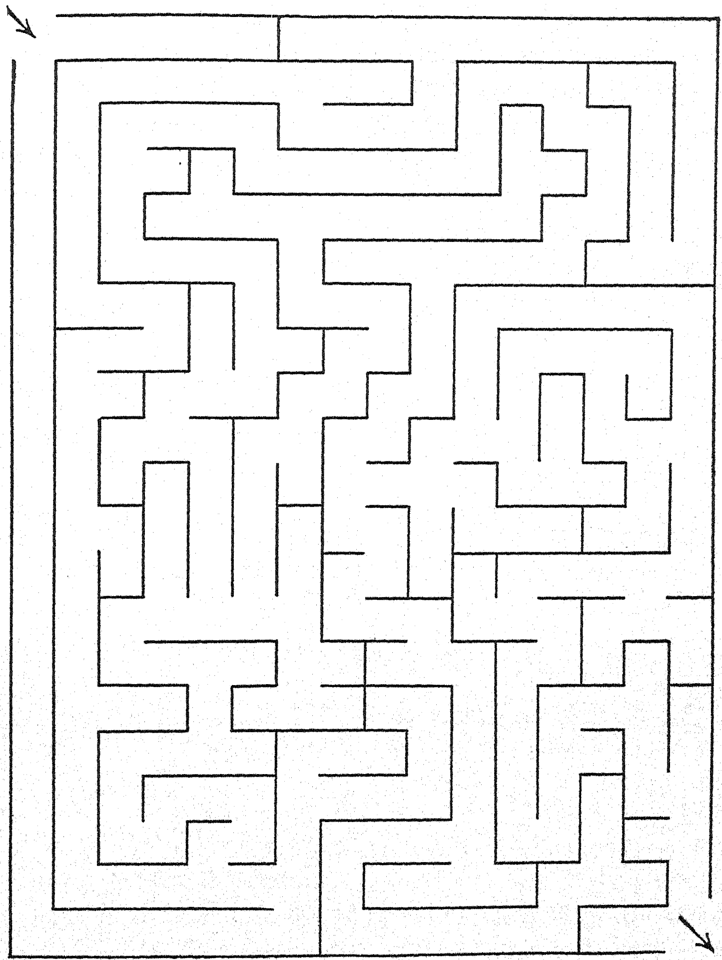

FIG. 15.—A pencil maze. Draw a continuous line, following the most direct path, from the entrance to the exit. No erasures allowed.

moves. Many other concrete tasks are used in intelligence testing.

Group tests are given to many individuals at the same time. They are usually paper-and-pencil tests of the short-answer form now familiar to students. On the whole they may be less adequate than the individual tests, but some subjects do better in group tests than when working right under the eye of an examiner. Both forms may well be included in a

complete mental examination. Group testing got its impetus from the psychologists in the American Army in 1917-18. Their job was to examine thousands of recruits in short order and to discover which men were too dull to learn the duties of a soldier and which ones were bright enough to learn the duties of an officer or non-commissioned officer. They devised the Army Alpha, a group test consisting of several parts. The test booklet contained a page of arithmetical problems increasing in difficulty from the top to the bottom of the page; a page of information items; and a page of synonyms and antonyms to be distinguished, as for example:

ascend–rise	same or opposite?
nadir–acme	same or opposite?

These three sub-tests depend strongly, though not entirely, upon the subject's stock of *knowledge*. Among the other sub-tests were three that depended mostly on *alertness* and mental flexibility. One of these gave oral directions, as for example:

"Look at the row of letters. When I say 'Go,' cross out the last letter in the row, circle the letter F, and underline the two letters next after K. Go!" (10 seconds allowed.)

A B C D E F G H I J K L M N O P

Another required the continuation of number series, such as:

1	3	2	6	3	...	...
49	36	25	16	9	...	...

Another one, in the multiple choice form, presented "analogies" to be completed, as:

left — right : : up — front, rear, down, town
knife — blade : : arrow — spear, head, bow, shoot

There was also an Army Beta, intended to be fair to the illiterate subject and to the immigrant who knew no Eng-

lish. Instructions were given by pantomime and blackboard illustration. Beta included among other sub-tests: pictures to be completed by drawing the missing part; mazes; and "XO" series to be continued, as in the two lines below:

O X O X O . . . .
O X X X O O X X O O O X O X X X . . . .

Achievement tests. A glance at these tests will bring out by contrast the nature of the intelligence tests. A "trade test" is one kind of achievement test, intended to show how far an artisan has mastered the skill and knowledge required in his trade. An educational achievement test shows how much knowledge and skill the subject has obtained (and retained) in arithmetic, reading, or any school subject. Such a test differs from an ordinary school examination in being very carefully prepared and in being "standardized" by a preliminary tryout so that the norm or average score for each age and for each school grade is known.

The test items of an educational achievement test are drawn from the subject matter taught in the schools, while an intelligence test avoids any direct use of school materials. An achievement test would not make a fair intelligence test, for several reasons. First, it is too narrow in scope, being limited to school work and making no use of what a child picks up outside of school. Second, it would give an undue advantage to the child who is greatly interested in his school work. Third, it would give too low a rating to the very bright child who does not have a chance in the ordinary school to advance as rapidly as he is capable of doing. The slow child is prodded to keep him up to grade, but the bright child is given only the regular amount of subject matter to learn, and his achievement therefore lags behind his capacity.

The nature of intelligence as judged from the tests. Intelligence tests are designed to sample the individual's ability quite broadly. They utilize materials and activities that appeal to his spontaneous interests. If we look over the test items, asking what the subject (or *O*, the person tested)

must do in order to pass them, we glean some information regarding the nature of the intelligence that is being tested.

1. The test items are extremely *varied*. The abilities mentioned in the preceding chapter—verbal, numerical, spatial—are all sampled. The psychologist is attempting to measure general intelligence rather than any one special ability, but he need not assume the existence of a "general ability" (p. 74). It is enough that various abilities are given a chance to count in the score.

2. Many test items require the use of *knowledge*, knowledge built up in past experience. This is obviously the case with the vocabulary items and with all the verbal tests. It is no less obvious with the man-drawing test and with any picture item. It is not quite so obvious with the maze test, since the subject may never have encountered anything just like a maze. Yet even here he may be aided by past experience; he may have learned the advantage of being foresightful rather than hasty and impulsive. Probably some use can be made of past experience in performing any task that could possibly be devised. Intelligence, as tested, is bound to depend on the individual's past experience and so on the opportunities and stimulation that his environment has supplied, on his responsiveness and quickness to learn, and on his retention of what he has learned.

3. Very few test items, however, call simply for a recitation of something previously learned. Most of them place the subject in a somewhat *novel situation*. He is well acquainted with wood and coal but has never tried to explain how they are alike and how different. He has done many examples in arithmetic but each new example sets a new problem, especially when different kinds of examples are intermingled. Mingling of varied tasks, so characteristic of intelligence testing, has the effect of making each item a fresh problem. So the tests call for alertness and flexibility.

So far, we should judge that intelligence meets new situations by applying knowledge built up in past experience. Such a definition is all right as far as it goes but it does not

penetrate deeply into the process of "meeting new situations." Without attempting just yet any close analysis of the thinking process, we can see from some of the tests, such as the form board, that "catching the point" of the problem is essential. The subject must know what he is trying to accomplish. Then he must examine the situation closely enough to discover how things go together. He must see the interrelation of parts of the situation, as illustrated neatly by the maze, the number series, or the picture to be interpreted. Intelligence must consist largely in seeing relations and selecting those that will help.

MEASURES OF INTELLIGENCE: MENTAL AGE AND INTELLIGENCE QUOTIENT

In giving a Binet test the examiner first "establishes rapport" with the subject and makes a preliminary estimate of his intelligence. He then starts testing near the estimated level and works up and down the scale far enough to make reasonably sure what items the subject is able to pass. When the examination is completed, the subject's raw score is the total number of items passed or credited.

As in other tests, so here, the raw score is practically meaningless and must be transmuted into some form that will show *how the subject compares with other individuals.* Binet introduced the very convenient measure known as Mental Age (MA). *Age norms* are first established. Many children are tested within a month of their eighth birthday, for example. The average raw score of this sample of 8-year children gives the 8-year norm. The norms increase year by year up to about 15 years of age and thus provide a scale of mental ages. Any raw score can now be transmuted into a Mental Age. Any child or adult has a Mental Age of 8 years if his score just equals the 8-year norm. If his score falls just halfway between the 8-year and 9-year norms, his Mental Age is 8½ years. (To be perfectly correct we should speak here of a "Binet mental age," as we might speak

in other cases of a vocabulary age, an arithmetic age, an athletic age, a social age. Any ability that increases with age may provide age norms and be measured in its own scale of mental age.)

Mental Age is a measure of the individual's level of intelligence. To say that a child, or an adult, has reached the level of the average 8-year-old conveys a definite meaning. But it does not tell how "bright" he is. A child with a Mental Age of 8 years is a bright child if he is 5 years old, but a dull child if 12 years old. The Mental Age must be compared with the Chronological Age (life age counted from birth). A convenient way of expressing the relation is to divide Mental Age by Chronological Age (CA), so obtaining the Intelligence Quotient, the IQ.

$$IQ = \frac{MA}{CA}$$

With MA 8 years and CA 12 years, a child's IQ is $8/12$ or .67; another child with the same MA but a CA of only 5 years has the much higher IQ of $8/5$ or 1.60. The exactly average child of any age has an IQ of 1.00 because he just equals the norm for his own age.

Usually the decimal point is omitted and the exactly average child is said to have an IQ of 100. A child with an IQ over 100 is above the exact average for his age, and one with an IQ under 100 is below the exact average.

Of the two measures, MA and IQ, which is the better index of intelligence? Consider two children, 5 and 12 years old, each having an MA of 8 years. At the moment, both are at the same level, both have the same actual intelligence (so far as indicated by the tests). But the younger child is clearly much brighter, and this fact is represented by his higher IQ. Mental Age, then, is a measure of actual intelligence, while IQ is an index of brightness. If both these children maintain their respective IQs, the brighter one will eventually surpass the other and be the more intelligent adult. The IQ has predictive value, provided we can assume that

it is going to remain the same throughout the individual's further development. Whether the IQ does remain constant is a big question to which we shall return.

As a child grows up, his intelligence increases, he gains in Mental Age. His IQ need not increase: if it remains constant at 100, he is gaining in intelligence at the average rate of mental development; if it remains constant at 125, he is gaining 25 percent faster than the average; and if it remains constant at 75, he still is gaining though only 75 percent as fast as the average. Even psychologists sometimes become confused and speak as if a child's mental development were arrested because his IQ remains unchanged. If his development is arrested his Mental Age remains unchanged and then his IQ must decline as his chronological age increases.

The distribution of brightness in the population. The real point of intelligence testing lies in the comparison of one individual with another or, better, in the comparison of the individual with the age group to which he belongs. We wish to compare the 6-year-old with the general run of 6-year-olds, the 12-year-old with 12-year-olds, the adult with the general adult population. We wish to compare the individual's IQ with IQs in general. We therefore need to know the distribution of IQs in the population. We have to depend mostly on the results obtained from children, since they have been more adequately tested and sampled than adults. The distribution of IQs obtained from a large and fair sample of children (Fig. 16) doubtless holds good in the main for adults as well. The picture shows a gradual falling off on each side of a high point. The high point at IQ 100 shows that the largest percent of people lie near the average. The percent becomes gradually less on each side of the average. IQs of 120 are less common than those of 110, those of 130 are still less common, and so on. Below 100 it is the same: IQs of 90, 80, 70, 60 are progressively less common. There is no sign of bimodal distribution (p. 64). There is no gap anywhere, no separation between average and superior, between average and dull, or between dull and

feebleminded. These are not distinct classes of people; they are degrees in a continuous scale of brightness.

The exact significance of an individual IQ can only be learned from the distribution of IQs in the population. An IQ of 100, to be sure, tells us that the individual is exactly

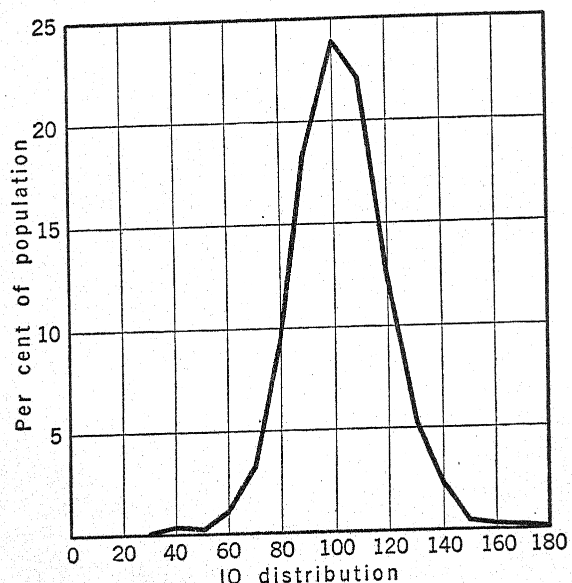

FIG. 16.—(Data from Terman & Merrill, 27.) Distribution of IQ in a sample of about 2,900 children, ages 2-18 combined. This sample was carefully selected, as explained on page 101, to represent as fairly as possible the native white children of the United States. The height of the curve above any point of the base line shows the percent of the child population having an IQ within 5 IQ points of 40 or 60 or 100, etc.

average for his age. An IQ of over 100 shows that the individual is above average, and one below 100 shows that he is below average. But *how much* above or below? Does an IQ of 130 denote outstanding brightness, an IQ of 70 exceptional dullness, or are such values quite common? We cannot judge from the IQ alone; we must know the range and distribution of IQs. The range extends from almost zero up to nearly 200. The distribution is shown by the curve or by the frequency of different values as shown in the percents below.

	Percent of the Population
IQ over 140	1
IQ 130-139	2
IQ 120-129	8
IQ 110-119	16
IQ 100-109	23
IQ 90-99	23
IQ 80-89	16
IQ 70-79	8
IQ 60-69	2
IQ below 60	1

From these percents we may see how exceptional any high or low value of the IQ is in the general population. An IQ of 140 is that degree of brightness which is surpassed by only 1 percent of the population. An IQ of 130 is that degree which is surpassed by $1 + 2 = 3$ percent; an IQ of 120 is surpassed by $1 + 2 + 8 = 11$ percent. Similarly, at the other end of the scale, an IQ of 60 represents a degree of *dullness* which is exceeded by only 1 percent, and an IQ of 70 represents a degree of dullness exceeded by 3 percent. According to this distribution, 46 percent $(23 + 23)$ of the population falls within 10 points of 100 IQ.

Re-interpreting the IQ. A fact which is rather disturbing but also quite instructive is that previous samples of the population, examined with the older Stanford-Binet tests, gave a different distribution, more closely clustered about the midpoint—a distribution in which 56 percent of the people (instead of 46 percent) fell within 10 points of 100, and in which only 6 percent surpassed IQ 120, only 1 percent 130, and only one in a thousand surpassed 140; and similarly in reverse direction at the low end. An IQ of 140 appears much less exceptional in the newer than in the older results. The cause of this discrepancy is not yet clear. If the cause lies simply in the more adequate new sampling of the population, the IQ has not changed its meaning and we simply know that both high and low IQs are more common than was formerly supposed. But if the cause lies in the changed

tests, then the IQ has taken on a new meaning such that the new IQ of 140, for example, is within reach of 1 percent of the population, while the old IQ of 140 can be reached by only one in a thousand.

The standard deviation of the IQ seems to have increased. (For the meaning of the standard deviation, or *SD*, see pp. 61, 88.) With the older Stanford-Binet, the accepted value of the *SD* was about 13 points of IQ, while with the new Binet the *SD* is 16 points. If this change is due to the changed tests rather than to the better sampling of the population, the following pairs of IQ values are equivalent:

	Stanford-Binet Test		*Newer Binet Test*
+3 *SD*	139	=	148
+2 *SD*	126	=	132
+1 *SD*	113	=	116
Average	100	=	100
—1 *SD*	87	=	84
—2 *SD*	74	=	68
—3 *SD*	61	=	52

We say these are equivalent values because the individual who stands 1 *SD* above the average in one test does just as well, in relation to his age group, as an individual who stands 1 *SD* above the average in another test. This whole system of measurement is relative and any IQ gets its exact meaning from the whole distribution of IQs. By use of the *SD*, as just illustrated, the IQs obtained from different tests can be reduced to equivalence (*8*, *13*, *22*).

We are not saying that an individual should necessarily obtain the same IQ from different tests. Since they use different items and tap somewhat different abilities, he will not do equally well in all. He will not get the same *SD* score in his age group and should not get the same IQ. But if he does equally well, in relation to his age group, and gets the same *SD* score, then he should get the same IQ.

To compare IQs from different tests or at different ages we must reduce them to a common denominator, and that denominator is the scatter, the *SD* of the age group. An adequate sample of each age group must be tested and the average and *SD*

for each group computed. The average individual in each age group will then be assigned an IQ of 100, and the individual who stands 1 *SD* above his group average will get an IQ of 116 (if we wish to adopt the new Binet Test values as our standard). Or we can discard the IQ and simply state the individual's *SD* score. This latter solution would suit the psychologist, but the public would prefer IQs which have become familiar and carry some intelligible meaning. What the public does not understand is that this whole system of measurement is relative. The IQ is not an absolute quantity of intelligence.

INTELLIGENCE IN RELATION TO AGE

"Constancy of the IQ." Two meanings might be attached to this phrase. The *average* IQ is 100 at every age, by definition, and therefore the average IQ is constant up through childhood. Moreover, as we have been arguing, the *distribution* of IQs must remain the same at all ages if any IQ value such as 80 or 120 is to have the same meaning. Constant average and distribution are necessary for this system of measurement. Whether the *individual's* IQ remains constant is quite a different question. John might go up and James go down without disturbing the average or the distribution.

Some fluctuation of the individual's IQ is inevitable, since no psychological measurement is perfectly precise and reliable. His state of health, interest and effort vary from day to day, and some test items suit him better than others, even at the same difficulty level. The examiner may be a bit too lenient or too strict in scoring some of the subject's responses—some of his definitions, for example, in the vocabulary item. It is really remarkable that intelligence testing is as accurate as it is, but we have to expect a change of a few points in IQ even when the subject is retested before any genuine change in his intelligence has time to occur. Tested *within a week* with the two equivalent batteries of the new Binet tests, children of high IQ were found to change about 6 points up or down, average children about 5 points, dull children about 2.5 points, on the average, and

some individuals of course shifted more than the average. Greater fluctuation is to be expected in bright than in dull children and in young than in older children.

With an allowance of 5-10 points for chance fluctuations, we cannot take seriously most of the shifts of an individual's IQ which are obtained on retesting after *much longer intervals.* Here, for example, is the record of a little girl, tested five times over a period of six years:

	Chronological Age		*Mental Age*		*IQ*
First test	6 years	8 months	5 years	6 months	83
Second test	7	1	5	4	75
Third test	8	2	6	10	84
Fourth test	8	7	7	0	82
Fifth test	12	10	9	10	77

She varies from 80 by only a few points up or down. Here is another girl with higher IQ and more variation:

	Chronological Age		*Mental Age*		*IQ*
First test	8	0	9	9	122
Second test	9	1	11	5	126
Third test	10	0	11	4	113
Fourth test	10	11	11	7	106
Fifth test	12	0	13	6	113

Individual records could be selected to give the impression of either constancy or inconstancy. Retests of many hundreds of children, brought together from several sources, show on the average a long-range shift of about 5 points up or down, with a few much larger changes. On the whole the individual child's IQ remains fairly though not absolutely constant, and the bright child becomes the intelligent adult. Thus the IQ obtained in childhood has considerable predictive value.

Here we must be on our guard against an unwarranted conclusion that is sometimes drawn from the usual constancy of the IQ, the conclusion that intelligence is completely determined by heredity and wholly unaffected by education

and other environmental influences. The flaw in this argument is the fact that under ordinary conditions the child's environment remains fairly constant. Logically his constant IQ could be attributed either to his constant environment or

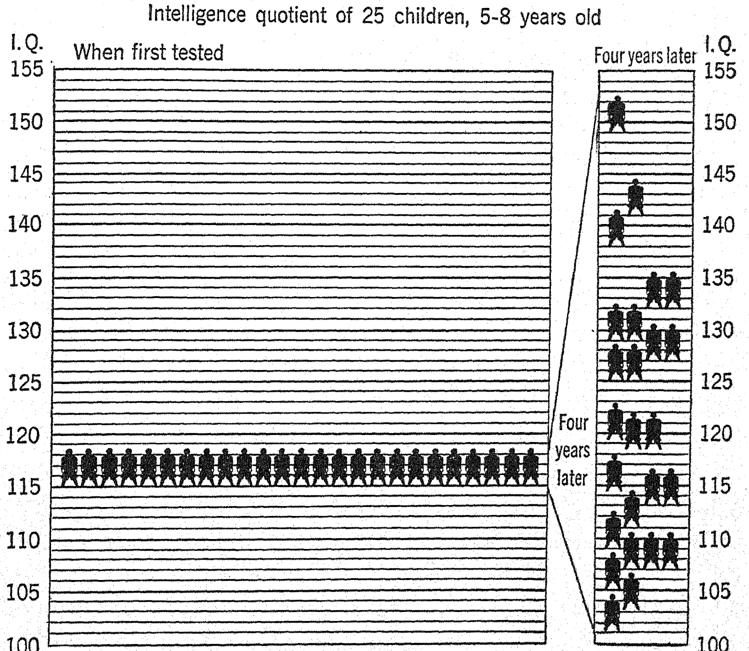

FIG. 17.—(Data from the psychological records of the Horace Mann and Lincoln Schools of Teachers College, Columbia University.) Changes in IQ of 25 children whose IQ was 115 on first test. During four years in these stimulating schools, the IQ of some of these children went up, while the IQ of others went down. The changes were not large in comparison with the whole IQ range of 0-200. The average change was a gain of 5 points.

to his heredity. Children relieved of the handicap of partial deafness or blindness sometimes show a definite and permanent rise in IQ. Their environment has in effect become much more stimulating. Other pronounced environmental changes are being tried out experimentally in order to discover how much can thus be accomplished. Knowledge certainly depends largely on the environment but regarding adaptability, alertness and mental grasp we are not so sure.

This question will come up for fuller discussion in a later chapter (p. 228).

Adult intelligence—at what age is it reached? To determine the average adult level of intelligence is an almost impossible task. There are two difficulties, one in devising adequate tests, and the other in obtaining a fair sample of the population.

Adults specialize in so many diverse directions that it is difficult to construct tests fair to all alike and reaching high enough to measure the superior individual. For example, high intelligence is demanded in the professions of law, medicine and engineering, but we cannot use legal, medical or engineering problems in tests that are to be fair to all adults. In their tests for adults psychologists have used items similar in type to those used with children, but more difficult. Many of the adult items are occasionally passed by a bright boy or girl of 12, but the superior adult is more consistently successful and gives the impression of being able to perform still harder tasks if the psychologist were only prepared to present them.

The *sampling difficulty* is serious. So long as practically all children remain in school, age groups can be obtained that are fair samples, and accurate age norms can be determined. But as soon as any considerable number of children or adolescents leave school, the remaining age groups cease to be representative. During the war of 1917-18 many thousands of drafted recruits, 21-30 years of age, were given the Army Alpha and Beta tests—a very large sample, this, but not entirely representative because of numerous exemptions from the draft. The average score made by the recruits was equal to that of 13-year children, indicating that intelligence ceased developing at about that age. A shocking conclusion, so it seemed—adults with the Mental Age of the 13-year-old child!

In standardizing the revised Binet tests (p. 101) great pains were taken to obtain fair samples of the age groups up through 18 years, and also to raise the "ceiling" of the tests so that the brightest 18-year-old could show his full power. The average score increased slowly beyond age 13 and

scarcely at all after 15. According to this finding adult intelligence is reached at the age of 15, though doubtless with considerable individual variation. Other samples have shown some increase up to 16 or 18 years of age.

The problem can be attacked by another method which largely avoids the sampling difficulty: test the same individuals repeatedly up through the teens, with due allowance for the improvement to be expected from the practice in taking tests. Some studies of this follow-up sort have found no advance beyond age 14, while others have shown a continued though slight improvement up to 18 or even 20 years of age (7, 27; see also a later discussion of the whole course of mental development, p. 222).

So far as we can now measure adult intelligence, the indications are that maturity is reached at the age of 15-18 years. One need not be shocked at such a conclusion. It would be fine if we could raise the adult level, but what would be the advantage of prolonging the growth period required to reach that level? Is it not better to reach full mental power during adolescence so as to be equipped for coping with adult responsibilities? Learning does not cease when growth ceases. The intellectually live adult goes on learning for many years. His increasing knowledge of the world in general as well as of his own affairs enables him to deal with his environment more successfully and, in effect, more intelligently, even though his grasp and power may not increase. In handling new problems he may be no brighter at 40 than he was at 20, but the problems he has to handle are no longer strictly new, because of his background of experience.

The IQ of adults. If Mental Age does not increase beyond the age of 15-20, while Chronological Age continues its inexorable advance, the individual's IQ, computed in the usual way, would continually decline. At 40 the ratio MA/CA would be only half what it was at 20. All IQs, high or low, would go down by this method of computation till they all reached the imbecile or idiot level. To avoid this absurdity it is customary to take 15 years as the CA of every adult.

Thus a person's IQ remains constant so long as his test score remains the same.

Since the test scores, far from rising continually during adult life, tend to fall off somewhat (p. 224), the individual's IQ will after all decline with increasing age. He will not score quite so high at 60 as he did at 40 or 20. To hold consistently to our definitions, we should compare the individual of any age with others of his own age. We should, for example, test a fair sample of 60-year-olds, compute the average and call it 100 IQ, compute the *SD* and use it in determining the IQ to be assigned for each raw score, according to some convention such as suggested on p. 116. For clinical purposes this system is desirable, since obviously the examining psychologist does not want to rate an old man as of low intelligence who is fully equal to the average for his age (*31*).

USES AND CORRELATIONS OF INTELLIGENCE

At the beginning of the chapter, intelligence was defined in a preliminary way as intellect put to use. It would be easy to point out many ways in which intellectual ability is useful in meeting practical situations, but the more pointed question, now that psychologists have succeeded in measuring something they call intelligence, concerns the use of this *tested intelligence*. The practical question is whether the individual differences revealed by the tests count for much in the daily activities of the child or adult. If they do, good use can be made of the tests in educational and vocational guidance. A boy can be advised to go to college because his IQ is high enough to make success reasonably sure, provided of course he will do the work. Or he may be advised not to attempt a professional career because his IQ is not high enough. The vocational counselor needs to use good judgment, not depending on the results of an intelligence test alone but taking into account several other factors: character and personality, environmental conditions and prospects.

Aside from the many practical applications of intelligence tests, it is important for the psychologist to know how the thing he measures counts in life. Only so can he understand fully what he is measuring. We have been seeking light on tested intelligence by examining the testing operation. We found that the tests were such as to demand the application of previously acquired knowledge for the solution of new and varied problems, and that high intelligence demanded the intellectual grasp of complicated situations. Further light on the nature of tested intelligence can be had from a study of its correlations. What can the child of higher MA do that one of lower MA should not undertake just yet? What achievements prove to be within reach of the individual of high IQ but not within reach of the average individual?

Intelligence and scholastic success. The children of six years and thereabouts, who assemble each year to begin their formal schooling, are of all degrees of brightness except the lowest. They present almost a true picture of the general population as regards the distribution of IQ. Some of these children find school work easy and make rapid progress, "skipping a grade" once or twice in the next few years. Others make slow progress and have to repeat grades, and most of the children are strung out between these extremes of early scholastic success.

There is a good correspondence between the child's IQ, obtained from a test, and his school success. The correlation is especially close when each child is given an opportunity to advance at his own rate.

An interesting experiment on this matter was tried in a large public school system (New York City). From the 8-year-old children two special classes were formed, twenty children in each class. All were of high intelligence, but one class consisted of children with IQs from 152 to 183, averaging 165, and the other class ran 20 points lower, averaging 146. The home environments were excellent and averaged the same for both groups. During the three-year continuance of the experiment each child was allowed to advance

at his own rate, under the supervision of good teachers. The result: both classes advanced much more rapidly than an average group, and the class of the highest IQs outstripped the other. It was definitely superior in the more difficult and complicated work such as fractions, science and the understanding of connected passages, while the two classes were about equal in simpler work such as ordinary addition (*11*).

As the higher grades of the elementary school are reached, the children of low IQ lag and reach their limits. Probably an IQ of 90 is needed to master the regular work of the eight grades, of 100 to finish the junior high school, and of 110 to do a satisfactory job with the senior high school curriculum, though these numbers are only rough indications. Many colleges try to limit the freshman class to those of superior ability, succeeding to such an extent that intelligence tests of freshmen show them to represent a high selection from the general population.

But the correspondence between test score and academic achievement is less close in the secondary than in the elementary school and still less close in college. The correlation between IQ and school work goes down from .75 in the lower grades to .60-.65 in the secondary school and to .50 in college. The reason is, in part, that the college group is so highly selected. Those absolutely incapable of doing the work have been eliminated and the achievement of the student depends very largely on his interest. Some students of high intelligence prefer to direct most of their energies elsewhere, and some, it must be admitted, prefer to loaf for a few years. In short it is often a question of motivation rather than of ability.

Intelligence and genius. A very high IQ is no guarantee of success in science, literature, art, politics or business. Besides the matter of motivation there is the question of special abilities. One may have high intelligence without special ability in music or writing or leadership. In fact the correlations between these special abilities and intelligence, so far as they have been measured, are rather low though always

positive. Yet it is very doubtful if anyone can make a great success in any special line without having high general intelligence. Though the great geniuses of the past were not subjected to an intelligence test, an estimate of their IQ can sometimes be made on the basis of their performances during childhood. These gifted individuals seem always to have been very bright children. When we find Ralph Waldo Emerson composing a long poem at the age of ten, of which the following lines are a sample:

> "Six score and twenty thousand 'gan the fray,
> Six score alone survived that dreadful day,"

we say that the performance is beyond his years, and that his mental age exceeded his chronological age, and his IQ must have been well over 100. Similar indications are found in the childhood records of all great men whenever those records are at all adequate. Other qualities besides intelligence stand out in the records which must have contributed greatly to their greatness later in life—such qualities as persistence of effort, confidence in their own powers, force of character, ambition or the desire to excel, and often a passionate fondness for some chosen field. The intense concentration of the genius in his own field is something most of us never experience in our own lives (*26*, Vol. 2).

Intelligence and occupation. A certain minimum intellectual ability is needed for success in any given occupation. In routine clerical jobs, an MA of 10 years is about the lower limit for acceptable work. For higher clerical work the minimum is much higher, and it is still higher in the professions. Occasionally a boy's parents are determined he shall be a professional man, though his IQ is not over 100. The boy puts forth the most strenuous efforts but is unable to "make the grade." One might expect young people to choose their lifework with due regard for their ability to do the work, but this expectation is only partly supported by the facts. On the average, to be sure, professional men score the highest in intelligence tests, bookkeepers and clerks rather high, mechanics fairly high, unskilled laborers the

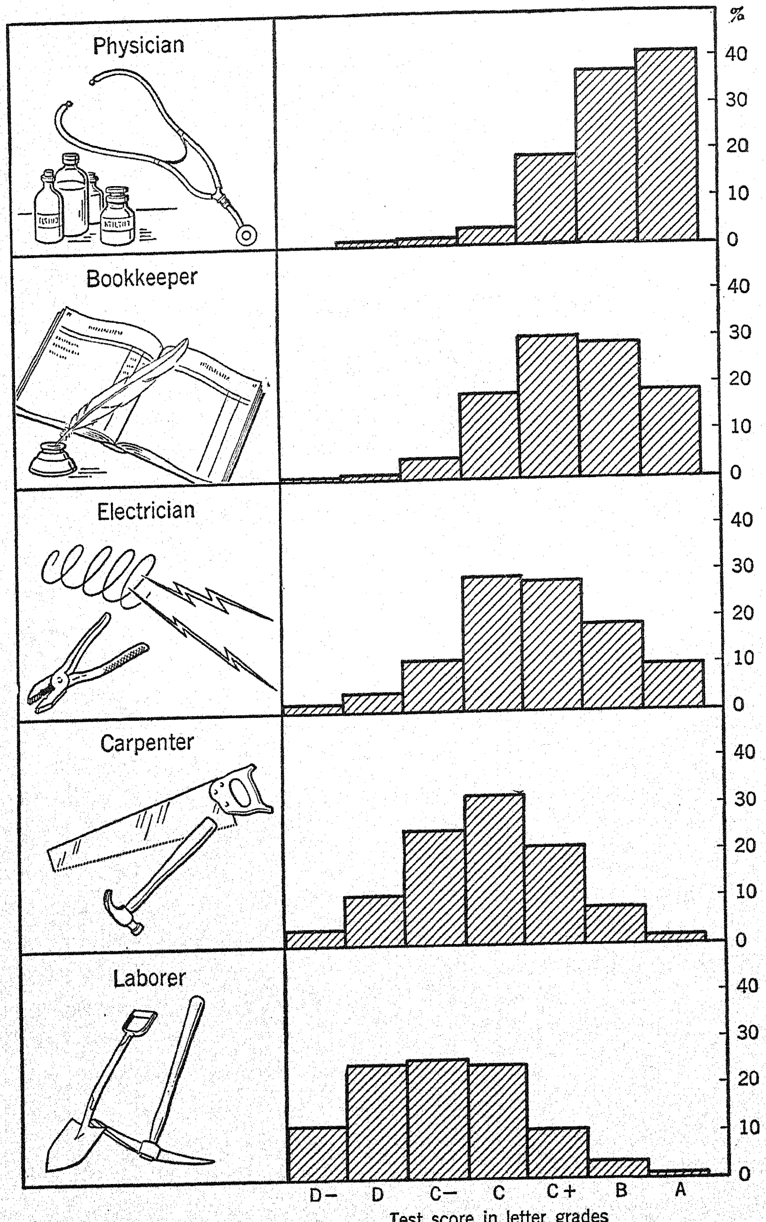

FIG. 18.—(Data from Yerkes, *32*.) Intelligence in different occupations, according to the Army tests of 1917-18. Two facts stand out clearly: the higher scores in the more intellectual occupations, and the large overlapping of all the occupations. The A grade was attained by a large absolute number of the laborers, though by only a small percent.

lowest; but the spread of scores in each occupation is enormous (Fig. 18). Some professional men get low scores and some laborers high scores, the most intelligent laborers surpassing the least intelligent doctors and lawyers. As things go today, with little expert vocational advice, many men are misfits in their chosen occupations.

Now here is a challenging fact: children grade off more or less according to the occupations of their fathers. The children of professional men and executives score highest in an intelligence test, the children of unskilled laborers lowest. This gradation is found in many localities and in various countries. A sample of the results is shown in the adjoining table.

IQ AVERAGES OF CHILDREN WHOSE FATHERS ARE IN DIFFERENT OCCUPATIONAL GROUPS

	Occupation of Fathers	*Average IQ of Child*
I.	Professional	116
II.	Semiprofessional and managerial	111
III.	Clerical, skilled trades, and retail business	107
IV.	Rural owners: farmers, etc.	95
V.	Semiskilled, minor clerical, and minor business	104
VI.	Slightly skilled	99
VII.	Day laborers, urban and rural	96

These are the averages obtained by Terman & Merrill (*27*) from their sample of the U. S. population. Similar occupational differences have appeared in test results obtained in England (*6*); in Soviet Russia (*24*); in Poland (*21*); in Czechoslovakia (*33*); and in Japan (*14*).

The table shows averages only. The range of intelligence among the children of each occupational group is almost as wide as the range for the whole population. Bright children as well as dull children are present in every group. The distributions of the children, even more than of their fathers in Fig. 18, overlap extensively. The absolute number of bright children emerging from the less intellectual occupa-

tions is very large, but the intellectual occupations furnish much more than their quota of bright children, especially of the very brightest (*4; 26*, Vol. 1).

Recognizing that the occupational status of parents is only a minor factor in determining the intelligence of their children, we ask why it should be any factor at all. Why should children differ at all in intelligence according to the occupations of their parents? Several explanations are possible. According to the *environmental* explanation the children who grow up in the homes of intellectual parents are stimulated to intellectual activity throughout childhood and consequently develop high intelligence, while those in unintellectual homes lack the necessary stimulation. According to the explanation by *heredity*, parents who are naturally intelligent tend to have children who are naturally intelligent, while the naturally stupid parents pass on their inferior heredity.

We could choose sides and debate these two alternatives without ever reaching a decision. The mere fact that children resemble their parents in intellectual activity proves nothing for either heredity or environment, since the parents who provide good heredity usually provide good environment as well. With the men in every occupation differing as much as they do in intelligence, with parents differing as they do in attention to their children's mental development, with the children of successful men often very weakly motivated and the children from the less intellectual occupations sometimes very strongly motivated to rise in the world, too many variables are involved for any clean-cut study of heredity and environment. The whole question is considered in a later chapter (p. 228).

Urban and rural intelligence. Country children have usually been found to make lower intelligence test scores than city children. The city children average about 100 IQ or a little higher, the country children about 90-95, with the usual wide range in each group. Here again the question of heredity or environment can be raised. The city and its occupations may attract the more gifted individuals, or the

city environment may be more stimulating to intellectual activity. Exactly how the city environment is superior is not easy to see, though the city dweller is apt to assume it so, as a matter of course. The majority of eminently successful men as judged from *Who's Who* were born in cities and towns, but about 23 percent of them were born on farms, and sometimes the rural environment was distinctly stimulating, especially perhaps to the future scientist (*30*).

The rural average is not always below the urban. In one of the fairest samples ever tested, all the children born in Scotland on four particular days in 1926 were given the Stanford-Binet at the age of 9-10 years. The average IQ of these 874 children was almost exactly 100, and the SD of the distribution was 15.6 points. The country children averaged just as high as the city children. It is pointed out that all the country schools in Scotland are supplied with well-trained teachers (*18*).

One reason for low scores by the country children is that the tests, prepared as they are by city people, unintentionally draw on the city child's environment more than that of the country child. Consider the following test item, a disarranged sentence to be put in order

for the started an we country early at hour

The country child would have to substitute "city" for "country" in order to make good sense. Many similar examples can be found in the standard tests (*12*). The country child's mind may be as active as the city child's but occupied with different things.

The same question can be raised regarding children from different occupational groups. Are the tests, prepared by professional people, equally fair to all the groups, including those engaged in mechanical and outdoor work? As soon as we attempt to compare children from different environments, the question comes up whether the test items are equally fair for all.

Intelligence in different races. As students of psychology we have no racial prejudice and do not *care* which race is

superior in intellectual ability or whether all the races are equal. We should like to know the facts and we should hate to be taken in by deceiving appearances. Superior civilization is no criterion of superior national intelligence, because no nation has created its own civilization entirely, and the greatest nations have been the greatest borrowers. The Greeks borrowed the alphabet from the Phoenicians and the beginnings of their art from the Egyptians. Can we use the intelligence tests for comparing nations and races?

Children of several races have been tested in American schools and the results are definite enough: White, Chinese and Japanese children score about the same, Indians and Negroes lower. Here are some results obtained in California by use of the man-drawing test (*10*).

Children of White American parents, average IQ	100
Children of Chinese and Japanese parents	101
Children of Indian parents	86
Children of Negro parents	83

There are also differences between the various groups of immigrants from Europe, the Jewish and German children (in American schools) making higher average scores than the French and Italian children (*3*).

Three alternative explanations are possible here again. (a) One race or nation differs in its hereditary mental capacity from another—the Chinese race being naturally superior to the Indian, and the German stock naturally superior to the Italian. (b) All races are potentially equal, but the Indian child does not develop his full capacity because his environment is not intellectually stimulating. (c) All races are not only potentially but even actually equal in total ability, but their intellectual activity takes different directions; consequently they develop different specific abilities, and some races do not develop along the lines of our tests.

According to this last view all cultures possess equal stimulating value, for the child at least, but they differ so much in content as to make it almost impossible to construct a test that shall be equally fair to all. A test prepared by Euro-

peans or Americans is almost sure to include items which are unsuited for individuals from radically different cultures. At first thought the man-drawing test, the form board and the maze should be fair to individuals from any culture group. But there are subtle differences in background. When the tests call for rapid work they penalize children from communities where speed is of no account. When they require the subject to rouse his energies and do his level best they penalize groups accustomed to exert themselves only in serious situations, and favor those accustomed to competitive games and stunts. How much allowance should be made for these factors when comparing different races or communities we can only guess, and therefore our intelligence tests at present are of little use for proving or disproving racial differences in intelligence (*15, 16*).

One sure conclusion can be drawn from intelligence tests of racial and national groups. Within each group there is a wide range of ability. Some Indians surpass the Chinese average. Many negroes surpass the white man's average. Of the European immigrant groups that test rather low, some individuals have passed the severe test of obtaining the Ph.D. degree. Individual differences, in short, are much more important than group differences. From an individual's race or nationality you can infer practically nothing as to his intelligence.

Intelligence and conduct. It is an important question whether the more intelligent person is apt to have the better character. Such a relationship would be expected, since the more intelligent person would better understand the social effects of his conduct. Understanding the world better he should be more eager to participate in the best that society is seeking to accomplish. But if his interests are wholly self-centered, his intelligence will merely make him shrewder and better able to keep within the limits of the law or to cover his tracks when he transgresses those limits.

Attempts to measure goodness of conduct and to correlate this variable with intelligence have usually shown a positive correlation though not a very high one. The most intelli-

gent individual is not necessarily rated the most moral or the most co-operative, but the tendency is in that direction.

Bad conduct may result from a disproportion between the individual's abilities and the duties assigned him. If his job is below his intellectual level, he may become heedless and mischievous. An intelligent employee on a dull routine task is likely to be a slacker and a quitter. On the other side, one whose intelligence is inadequate for his assigned work is constantly humiliated by failure, and is likely to become sullen and rebellious—in short, to develop an antisocial feeling. A dull big boy in a school grade too high for his mental age finds it much pleasanter out of school and may drift into habitual truancy and so make a start toward conduct forbidden by the community, i.e., toward *delinquency*. Some criminal careers begin in just this way, and in such cases low intelligence is an indirect factor in antisocial conduct. But notice that it is not low intelligence alone that gives rise to delinquency, but low intelligence combined with social demands (here school demands) which are unsuited to the individual's ability. When the school, perhaps by the introduction of shop work, provides an opportunity for such a boy to enjoy a measure of success, his career is apt to be very different.

Since the invention of the tests, much attention has been paid to the intelligence of criminals and young delinquents. The first studies indicated that a majority of delinquents were feebleminded, but with the improvement of test methods the findings have taken on a different color. It now appears that only a small fraction of delinquents are really feebleminded. Some are average and a few rather high in intelligence, but an IQ of 80-90 can be regarded as typical. As a whole, juvenile delinquents are rather a dull lot, but better in performance tests and especially in mechanical aptitude tests than in tests like the Binet or the Army Alpha. Adult criminals average higher than the juvenile group, for several reasons. The most stupid ones are early confined in institutions for the feebleminded, and the opportunities for gain (as

in racketeering) draw in a number of young men of average or even superior intelligence.

The cause of delinquency and crime is not to be found in any one factor, whether low intelligence or emotional instability or poor home environment or inferior neighborhood conditions. Sometimes one factor and sometimes another appears to be more influential. An adolescent girl, badly managed at home, may drift into sex misconduct, especially if she is handicapped by low intelligence. A boy seeking adventure joins the gang in his rough or careless neighborhood and is drawn into lawless exploits. Some individuals, however, resist environmental pressures so well that they hold to a steady course in spite of many adverse factors (*2, 5, 19, 20, 23, 25*).

What the correlations show regarding the nature of intelligence. There is nothing in the correlational results to throw out our previous conclusion that intelligence, as tested, calls for knowledge, adaptability to a new situation, and grasp of the essentials of the situation. We can now see that the tests do not measure the whole reach of these abilities, as we find them in superior adults. The tests are most adequate as an index of ability to master the school subjects, but they also serve as a partial index of aptitude for the more intellectual occupations, and of ability to comprehend society and keep out of antisocial activities.

Intelligence can probably develop in different directions according to the individual's environment. The tests are fairly successful in tapping what is common to children in the same culture group, but are not adapted for comparing radically different groups. Even city and country children, or children from different occupational groups, cannot be compared with complete fairness, though the differences found between such groups are small as compared with the differences between individuals.

Summary of the chapter. The nature of intelligence, as summarized in the preceding paragraph, has been one main theme, the other being the methods of testing intelligence and of stating the results of an intelligence test. Special at-

tention was given to the IQ, its distribution in the population, its constancy in the individual, and its real meaning.

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Chapter V

Personality

STILL keeping to our general theme of individual differences, we turn now from differences in ability to those less measurable but often very striking characteristics of the individual which fall under the head of character and personality. *Character* refers mostly to conduct that can be called right or wrong, that meets or fails to meet the accepted social standards. *Personality* refers to behavior which, though not necessarily right or wrong, is pleasing or offensive to other people, favorable or unfavorable to the individual's standing with his fellows. The distinction is not always sharp and for our purposes may be disregarded.

If your friend, in applying for a position, has named you as one of his references, you will be asked by the appointing officer to tell what you know of the candidate's ability and experience, and also what you know of his personality. In replying you state, so far as you conscientiously can, that the candidate has a pleasing yet forceful personality, that he is energetic and persistent but cheerful and even-tempered, self-reliant without being selfish, and that he co-operates well with other members of a group. There are literally thousands of adjectives that can be used to characterize a personality, and certainly these qualities are of immense importance in work, in the home and in all forms of social life.

A moment's thought shows that these adjectives are properly adverbs. They tell how the individual behaves. One person behaves in a pleasing way, another in an irritating way; one acts energetically, another languidly. Personality words are not names of different activities, but names of

qualities of behavior. Any little act may "reveal the personality" by showing the individual's characteristic style of action. Personality can be broadly defined as the *total quality of an individual's behavior.*

A *personality trait* is some particular quality of behavior, such as cheerfulness or self-reliance. The total personality would be the sum of these traits, except that it is more than a mere sum of separate qualities. It has some unity. For example, a certain person is not merely cheerful *and* self-reliant; he is cheerfully self-reliant. Another person is peevishly dependent, and still another may be cheerfully dependent. Each individual has his own style or quality which is only roughly characterized by naming his traits.

Personality is potentially the most interesting part of psychology. If a psychologist is asked to "Tell us something about your subject" he will probably ask his audience to be more specific. "What topic would you like to have me discuss?" "Oh, tell us about personality," is usually the answer. "Well, what would you like to hear about personality—in case I know it myself?" The two most likely questions are: (1) how to judge personality, and (2) how to develop and improve personality. "Tell us how to size up a new acquaintance, so as to know whether he is going to wear well. And tell us how to get personality ourselves." This second question broadens out when one is responsible for other people. A parent, teacher, priest, psychiatrist or psychological adviser wants to know how to improve the personality of other people.

When addressing students, the psychologist is not going to hand out a set of mechanical rules for judging or improving personality. His job with students is to lead them to some basic knowledge. Just as the electrical engineer bases his practical control on scientific knowledge of electricity, so the psychological engineer must proceed from a knowledge of cause and effect.

The present chapter gives a scientific approach to the problem of judging personality, and the following chapter

looks into the question of causes or sources such as must be known by anyone who seeks to improve personality.

DESCRIBING PERSONALITY

It is not easy by any means to give an adequate picture, description or characterization of an individual's personality. It is not easy to obtain an intelligible description from those who know him. You may be interested to learn about a certain person so as to judge whether he will make a good friend or a desirable addition to your group. You wish to know whether he will be a congenial and useful member of the group. Someone who knows him tells you, "Well, he's this sort of a man," and goes on to relate an incident or example of the individual's behavior, leaving you to draw your own conclusions. Instead of dramatizing in this way, your informant may be more analytical and apply a number of descriptive adjectives to the person. Either the dramatic picture or the analytical description is likely to leave you with a false or inadequate impression of the unknown man. An adjective by itself is abstract and you may go wrong in giving it concrete meaning. An incident shows how the person behaved in a concrete situation, but you wish to know how he would behave in other situations.

Perhaps your informant tells you he has found the person in question very congenial. That is something worth knowing, but it is not enough. Because *A* and *B* are congenial it does not necessarily follow that *A* and *C* will be so. Congeniality is a relation between two (or more) people and depends on the *interaction of personalities*. If we make a study of happy and unhappy marriages, hoping to discover what personality traits make for the one or the other, we find all kinds of people happily married and all kinds unhappily. We find some very amiable people unhappy and some unamiable ones perfectly contented. The aggressive and the yielding, the touchy and the thick-skinned, the stable and the unstable, all may be either happy or unhappy in

wedded life. It depends on the interplay of personalities and to some extent on external circumstances (*32*).

From such facts as these some students of the subject draw the conclusion that personality is not an individual matter. They say it is a relation between individuals. They deny that the individual has any personality apart from his associates, and ridicule any attempt to describe an individual's separate personality. Such a conclusion, however, goes far beyond the facts and is quite inconsistent with certain facts. Though all kinds of people are happily married, it does not follow that you could mate two individuals at random and assure them of wedded bliss. Individuals differ, and therefore pairs of individuals differ. If the individuals were all alike and neutral in respect to personality, then pairs of individuals also would be all alike, which is obviously contrary to the facts.

Nor should we accept the assertion that personality reveals itself only in social life. An irritable man quarrels with his tools, a persistent man sticks to a lonely task. A man may "let himself go" when alone more than in company. He may like to give vent to a buoyant *joie de vivre* by singing at the top of his lungs, but does so only when safely out of hearing.

But what can we mean by saying that a person now dozing in an easy chair is a friendly person, or irritable, persistent, vivacious, or that he "possesses" any other trait? We mean about the same as when we say that he possesses a certain ability, unused at the moment. Our evidence in both cases is that we have "seen him do it." We assume with good reason that he still retains, carries around with him, the ability or the trait that he has demonstrated in active behavior. Personality is a relatively permanent structural characteristic of the individual (p. 27).

Dimensions of personality. Of the enormous number of trait names in common use, many come in pairs of opposites, as cheerful–gloomy, masterful–submissive, kind–cruel. Because opposites are so convenient we easily slip into the error of classifying people as either cheerful or gloomy, as if these were two sharply separated classes. The distribution

curve (p. 61) stands as a warning. People do not fall into contrasting types. They scatter all the way from one extreme to the other, with the greatest number falling in the middle of the range. So we find whenever we are able to measure people in any respect. It may not be possible to measure cheerfulness but certainly people are more or less cheerful rather than either cheerful or gloomy. The best way to utilize the everyday vocabulary of trait names is to place a pair of opposites at the ends of a line and regard this line as a dimension of personality, with individuals located at different parts of the line.

These dimensions are analogous to the verbal, numerical and spatial abilities which are dimensions of ability. The question is whether any outstanding dimensions can be identified in the field of personality. By using pairs of opposites we could find names for hundreds of possible dimensions, but they would not be wholly different. The many traits doubtless overlap and could be reduced to a smaller number. The correlation method provides a check. Arrange a good sample of the population along the cheerful-gloomy dimension, and arrange the same individuals along the kind-cruel dimension. If the order of individuals is nearly the same in the two arrangements, i.e., if the correlation between the two arrangements is high, the two dimensions are largely the same. If the correlation is low they are the same to a slight extent. If the correlation is zero they are separate and independent dimensions, like latitude and longitude in geography. It would be fine if personality could be reduced to a small number, say a dozen, of independent dimensions, but so far we have no evidence that this is possible. Correlation does at least enable us to systematize to some extent the chaos of personality traits. Certain traits, shown by their high correlation to have much in common, point toward the existence of some less obvious, deeper-lying trait. So a science of personality, or at least of individual differences in personality, is being gradually worked out.

One obstacle in the way of any penetrating analysis of personality is our inveterate tendency to tell how we like a

person instead of seeking to discover what it is about him that we like or dislike. We say he is pleasing, interesting, useful or in some similar terms state his *value to us.* Often we give our impression of his moral value, by calling him good or bad. None of these value judgments really describe the individual. We need to ask *in what way* he is pleasing, interesting, good or bad. We need to lay our own feelings aside and see him as objectively as possible. Even if he is offensive to everyone else and not merely to ourselves, so that he must be "really" offensive, calling him offensive does not get us far toward a description of his personal characteristics nor help us much if we undertake to improve his personality. As soon as we try to be more specific we find ourselves forced away from valuation toward a study of cause and effect. Offensiveness is only an effect; we must discover the characteristics of the individual that make him offensive.

JUDGING PERSONALITY

To the student who desires to develop his power of judging character and personality the psychologist can offer no easy short-cut system of rules and signs. He has no faith at all in astrology, for it seems to him that the distant stars can have about as much influence on your behavior and fortunes as your actions have on the star. Coming down to earth, you may find the psychologist not quite so skeptical regarding the anatomical signs stressed by some self-styled character analysts, like the shape of the chin or size of the nose; for the bodily structure and the behavior of the individual both belong to the same organism. But the psychologist would expect only very low correlations between anatomical and behavioral traits, and the correlations he finds are actually too low for any practical use (*22*). From a person's forehead, nose or chin you can learn practically nothing regarding his character. When the character analyst is successful, it is by observing the subject's behavior and not his mere anatomy (*15*). You can learn something from the subject's facial *expression*, or from his speaking voice, or from a two-

minute silent film of the subject in action (*8*). You can learn something from his written themes or essays, and the expert can even make some fair deductions from his handwriting. Some people reveal their personal traits more freely than others, some traits are more open than others to inspection, and of two judges, both afforded the same opportunities for observing an individual, one will obtain a much truer and fuller impression than the other.

To be a good judge of character, you obviously need experience. You must know the particular person to be judged and other persons to compare him with, and you need experience in checking first impressions against later acquaintance, and in viewing people objectively, not as friends or enemies but as persons in their own right, with their own problems and their own resources and handicaps.

Interviewing. It has been said that to know a personality you must live with the individual for three months, preferably seeing him in a variety of situations. A vocational or psychological adviser has to get along with somewhat less than this. An hour's interview must often suffice. A good interviewer quickly establishes "rapport," by winning the subject's confidence, putting him at his ease as far as possible, overcoming the subject's tendency to be on the defensive or to assume a pose, and in short securing the subject's co-operation in the effort to understand his problems, assets and liabilities. The good interviewer has a genuine interest in people and still maintains the objective attitude. Since he interviews many individuals, his real task is that of comparing one with another. He must place them to some extent in the same situation, following a standardized plan which is however somewhat flexible and responsive to the person interviewed. From the information given by the subject and from his behavior, the interviewer is able to form some judgment regarding his personal characteristics. The good interviewer avoids premature judgment. Knowing that first impressions are often misleading he maintains the attitude of suspended judgment till the subject has a good chance to reveal himself. Even the best interviewer makes some mis-

takes, if only because the same visible behavior does not always spring from the same cause. The subject who will not look you straight in the face may have a shifty character, or may be very docile and submissive, or may simply prefer some less interesting object to fix his eyes on while thinking out the answer to your question. Good interviewing is a fine art (*1, 40*).

The case study. A person becomes a "case" because of some breakdown or misconduct, usually, and the study is aimed at his rehabilitation. The methods have already been indicated under the head of "case history" in the first chapter of this book. His parents or other early associates and especially the subject himself are interviewed for the purpose of reconstructing his personal history during the most formative years. His academic and occupational history are scrutinized. He comes under the eye of several specialists who observe him from their respective points of view and bring their findings together in staff meeting. His abilities are tested. His desires, hopes and plans, his goals and the means he tends to adopt for securing his goals, are part of the picture. The whole inquiry is directed toward a recommendation as to how the subject may best be put on his feet, and as far as possible he himself has a share in formulating this recommendation and accepts it as the most hopeful plan of action. Subsequent check on the success of the recommended "disposition of the case" is an essential part of the whole procedure.

Though so incisive a case study is seldom possible except where the subject has got into trouble and is in desperate need of help, the college student would probably derive some benefit from being the subject of a somewhat similar study, and the student of personality would learn something from conducting such a study. It might be feasible for two students to collaborate, each serving as subject to the other, as in a laboratory experiment. The two should be reasonably congenial but not emotionally attached to each other—for the study must be objective. Without attempting to reach the deep undercurrents of personal life, the study could bring

out the background, interests, attitudes, goals and traits and work up to a comparison of the two personalities.

The individual student may even find it instructive to take himself as a "case," and examine his interests, hopes and prospects, viewed in the light of his life history, with emphasis on formative influences in family, neighborhood and school, and the satisfactions and frustrations of his life so far. Intimate personal autobiographies of young adults sometimes make very illuminating sources for the study of personality (7, 20, 29).

PERSONALITY TESTS AND MEASUREMENTS

In describing an individual we compare him directly or indirectly with others. If we do not think specifically of any other individuals at the moment, we compare him with the general run of people. Experience with various people has given us a rough idea of the average person and of the scatter along any dimension. It is the same in judging personality as in judging ability or even bodily size. When we exclaim, "Isn't he a big fellow!" we need not be thinking of anyone else except the individual now before us but we are evidently comparing him implicitly with the average and range of people with whom we are familiar. If we should be transported to Brobdingnag, where all the inhabitants are giants, our scale of bigness would be altered and our "big fellow" would appear comparatively small. In the same way a companion whom we think exceedingly grumpy may later seem a very mild case by comparison with certain other individuals. One approach to a science of personality is by way of individual differences. Attempts are made to locate individuals on various dimensions of personality, and to measure personality traits as far as possible. The numerous methods used are classified under the head of rating scales, questionnaires, and personality tests.

Rating scales. Instead of saying that a person is "very persistent," "moderately so," or "lacking in persistence," we must attempt to be more precise and quantitative. There are

many situations where an adviser or supervisor will make good use of accurate estimates if they can be obtained. Teachers are rated as to teaching ability, students as to promise of academic and other success, army officers in respect to general value to the service. Promotions and other important decisions are sometimes based, in part at least, on such estimates.

An estimate can be expressed as a percent, the most cheerful person imaginable being called 100 percent cheerful, the average person 50 percent, the low extreme 0 percent. Or a scale running from 0 to 5 can be used, 0 and 5 being used for extreme cases, 1 and 4 for markedly high or low individuals, 2 for just below average and 3 for just above average in the designated trait. The "graphic rating scale" is convenient. A certain dimension or trait is represented by a line and the individual's estimated place in this dimension is denoted by a check mark somewhere along this line. For example, rate some acquaintance in the six traits shown in Fig. 19. Or take two acquaintances, denoted by *X* and *Y*, and rate them both on the same chart.

The average individual in any trait belongs at the middle of the line. Raters are likely to commit the "generosity error" by placing their acquaintances on what seems to be the more desirable side of the average. Some raters are more generous than others, but there are statistical means for correcting this error, provided the same rater rates a large number of individuals, so that his distribution can be compared with the normal distribution (*10*).

Another error is known as the "halo effect." If an individual creates a favorable impression by his excellence in one trait, you are apt to rate him near the top in every trait without discrimination. If he has created a bad impression at one time, you find it difficult to shake off that impression when rating him in various traits.

The main advantage of using such scales is that the judgments of two or more raters can be pooled and averaged. Any single rater is likely to be one-sided or prejudiced, but the prejudices of different raters will often be in different

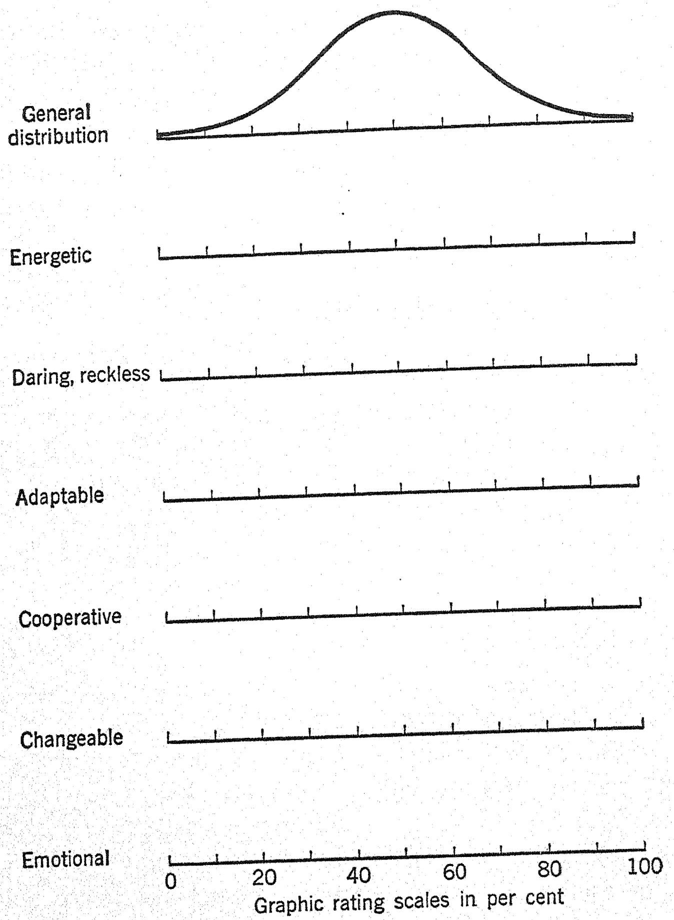

FIG. 19.—A graphic rating scale. In rating a person for energy, place him at the left of the line if he has no energy at all, and at the very right if he shows an enormous amount of energy; if he seems just about average place him near the middle. The distribution curve at the top is intended as a warning against the tendency to place everybody at one extreme or at other, and against the tendency to place everybody indiscriminately in the middle. With a large number of individuals rated in any trait, the marks should scatter about the mode in a distribution curve.

directions and neutralize each other, leaving a fairly unbiased average rating. Apart from prejudice, the different raters have seen the subject in different situations and obtained different impressions which need to be combined into the final rating in any trait.

In order not to present too optimistic a view of the value of pooled ratings, two qualifications should be mentioned. First, different raters may have the same bias, and their combined ratings will retain this bias. High school teachers rating a student have seen him mostly in the classroom and cannot easily escape the halo effect of the student's classroom performance. They may agree in rating a student low in the scale of ambition, while others seeing him in another situation would come away with quite a different impression.

The second qualification is that it does no good to pool ratings unless the single judgments are better than a mere guess. If three judges assign ratings to an entirely unknown individual, *X*, merely pooling the ratings will not yield any approximation to a true judgment. But if each judge has even a slightly true impression, their combined judgment tends to be truer still (*24, 33*).

When two or more observers are in a position to rate the same individual, there are two ways of combining their impressions. Each may make his rating independently of the others, the ratings being simply turned over to the computer who determines the average rating. Or the observers may meet and compare notes, and attempt to agree on the proper rating for the individual. Which method will give the truer ratings?—a nice little question in social psychology, and an important question for the student of personality. There is something to be said on both sides. Discussion is likely to bring out points not duly considered by some of the single judges, and one judge may have noticed important facts not known to the others. To that extent discussion is the better method. On the other side, a biased judge may over-persuade his colleagues and have undue influence on the final rating. And there are subtle forms of bias. The observer's own personality is a factor in his impressions of another person (*28*). The judge may be especially sympathetic or unsympathetic with the subject's personal traits. It is obviously difficult to check the validity of any personality rating, but as far as present evidence goes, discussion has a slight edge on the method of pooled independent judgments (*6, 20, 33*).

The reliability of ratings, as distinguished from their validity (p. 71), is determined by seeing how closely different judges, working independently, agree in rating the same individuals. Fairly good reliability (up to .80 or .90) has been obtained when the rating scale is carefully prepared and when the judges are well-trained and have sufficient acquaintance with the persons judged.

Self-ratings are found on the whole to run higher, in desirable traits, than ratings by other people, but there are exceptions and the tendency toward self-aggrandizement is largely offset by a tendency to rate oneself as "about average."

Questionnaires. In general a questionnaire is a list of questions to be answered in writing or by checking "Yes" or "No." It may be intended to obtain information on any matter. There is a special psychological type of questionnaire designed to lead an individual to reveal where he stands along a given dimension of personality. Suppose the dimension extends between the extremes, "finding trouble everywhere in life" and "finding no trouble at all in life." The appropriate questionnaire lists a large number of troubles.

LIST OF POSSIBLE TROUBLES

Poor general health	Shyness
Physical inferiority	Lack of self-confidence
Poor appetite	Mind-wandering
Insomnia	Foolish fears
Disagreeable dreams	Remorse
Mysterious aches and pains	Being criticized
Spells of dizziness	Being humiliated
Nervousness	Being misunderstood
Persistent tired feeling	Bad luck
Persistent headache	Unfair treatment
Persistent worry	Constant failure
Persistent irritability	The insecurity of life
Loneliness	The futility of life
Ennui	The wickedness of people
Lack of true friends	No pleasure in life

The subject is asked to indicate which of these are genuine troubles in his own life. The list usually consists of direct questions and may go into much greater detail.

The troubles included in the list are supposed to depend on the individual rather than mainly on accidents of his environment. A high trouble score suggests that the individual may need some expert advice in adjusting himself to his environment. These trouble scores vary enormously. A list containing about 200 trouble questions (*34*) was given to a large freshman class and the scores ranged from near zero to over 100, with the average about 35. Not all who report many troubles are "neurotic" in any proper sense, and not all patients whom the psychiatrist regards as "psychoneurotic" get a high trouble score in the questionnaire, though most of them do (*17*). Probably a neurosis consists not so much in being aware of many troubles as in "caving in" under their weight.

A trouble questionnaire has a rather high reliability in the sense that subjects do not change their scores much on a retest. They may change the answers to a few questions but still they check about the same total number of items. The question of validity is more difficult. Validity depends on the use to be made of the scores. If the purpose is to discover individuals of "neurotic tendency" who are likely to have a nervous breakdown or to become seriously maladjusted, the best check is to give the questionnaire to a large number of individuals, say freshmen, and to follow them through their college course and determine whether those with large trouble scores do develop personal difficulties from which those with small scores are free. On this basis the questionnaire is found to have some validity but not very much, since some students with large scores come through all right, while some with small scores allow their personal affairs to become terribly tangled (*12*).

If our object is to select the best candidates for a certain job where emotional stability is an asset, we must remember that the subject can easily misrepresent himself in filling out

a questionnaire. If he wants the job, say a government position, he can be coached in advance to make a low trouble score; so that a Civil Service Commission cannot legitimately use such a questionnaire. If he does not want the job, as in case of some drafted recruits to the army in time of war, he can be coached to give a very large trouble score in the hope of being assigned to a non-combatant service. Of course the malingerer is running the risk of being detected in a subsequent individual examination. Most individuals give sincere answers but a few sly liars can spoil the questionnaire for use in any highly competitive situation.

But if our object is to study individual differences in personality, the trouble questionnaire may still be of use. The first check on its validity would be to interview the subjects after they have answered the questionnaire. Perhaps they have misunderstood certain questions, or answered carelessly, or been too much influenced by their feelings on a particular day. They may have reported a "persistent tired feeling" simply because they had insufficient sleep the night before, or "bad luck" because of some recent happening rather than because of a feeling of being chronically unlucky. Even if the questionnaire stands up very well under this test, it still has to demonstrate its validity as an index of individual differences. Does the individual who makes a large trouble score necessarily suffer more from life's difficulties than the one with a small score? Does the questionnaire locate each individual in his proper place along the dimension extending between the extremes, "life so fine I wouldn't miss a minute of it" and "life so unbearable I have continually to fight off an impulse to suicide"? On this basis the validity of the questionnaire is probably only moderate.

Another unsettled question is whether there is a single trouble dimension of personality or whether on analysis it can be broken up into two or more.

We have used the trouble questionnaire as an illustration of a much-used method in personality studies. Questionnaires have been prepared for several other traits, and also for revealing the trend of the individual's interests and so as-

sisting him in the choice of a vocation (*30*). The questionnaire device is much used for measuring attitudes on such matters as religion, economic conservatism or radicalism, and nationalism versus internationalism. A list of questions might include the following:

Is the hope of permanent peace an idle dream?

Is an occasional war needed to maintain the vigor of a people?

Is it the duty of the peace-loving citizen to refuse to participate in any war?

Some of the questions are intentionally made much stronger than others. If possible an additional refinement is introduced by scaling the questions, i.e., by selecting such questions as are spaced out by equal intervals from one extreme to the other of the dimension in question. The attitude questionnaires can be used for comparing different groups, or the same group at different times, as before and after being subjected to certain propaganda (*5*).

Performance tests of personality. It is easy to test an individual's *knowledge* of the rules of good conduct or good manners or tact, but sometimes one who knows the rules does not obey them. We desire tests that will sample his actual behavior. The tests must be camouflaged somewhat, for you cannot very well tell the subject, "This is a test to discover how cheerful a disposition you have" or "This is a test to measure your willingness to co-operate." You might not get a fair sample of his behavior. In an ability test you discover what the subject *can* do, but in a personality test you wish to discover what he *will* do in life situations. Obviously it is going to be difficult for the psychologist to devise true tests of character and personality.

Many attempts are being made and some are fairly successful, especially with children. The camouflage employed is well illustrated by some tests for honesty and co-operation (*13*).

A spelling test, conducted in the schoolroom, contained rightly and wrongly spelled words with instructions to check each misspelled word with a pencil mark. Next day the

papers were handed back with a key by which the child was asked to score his own paper. To cheat he had only to change his wrong check marks, so that cheating was easy. But meanwhile a copy of the child's original check marks had been made by the experimenter, who thus detected all the cheating. In a similar test cheating was made more difficult by the use of a pen instead of a pencil in checking, to see if there was less cheating.

A handicap gymnastic contest was arranged outside of the schoolroom. One "event" consisted in squeezing a hand dynamometer as strongly as possible. Each child separately was shown how to use the dynamometer, squeezed it three times "for practice" and was then left alone with instructions to squeeze five times more in rapid succession and record his results on a card. Since fatigue makes it practically impossible to increase the squeeze in a rapid series of trials beyond what can be done in the first three trials, any considerable increase recorded by the subject was known to be spurious.

Among the tests for co-operation or "service" was one in which the children were given some new school kits containing pencils, erasers, rulers, etc., each child being then asked to contribute as much or as little as he chose out of his new kit, for the poor children of another town. The child's score on this test was the amount he gave away.

Similar to the honesty tests are tests of "overstatement." For example, in a vocabulary test the subject is asked to check the words he knows. Some fictitious words are included in the list, and checking of these is evidence of overstatement. A check list of "books I have read" can be similarly loaded with a few fictitious titles.

Some results of this type of tests will be discussed later in the chapter (p. 159).

Persistence, it would seem, must be an easy trait to test objectively. Give the subject a task without time limit and note how long he sticks to it. Here, too, some concealment is necessary, for if a group of subjects understand that persistence is the only point at issue, they may "gang up on" the experimenter and wear him out, beat him at his own game.

Tasks found useful in persistence tests include the building of as many words as possible from the letters of a given word; standing on the toes as long as one can and will; etc. Any such task brings in other factors besides pure persistence, but a battery of tests may measure persistence rather well. The persistence score shows almost zero correlation with intelligence, but an appreciable positive correlation with academic achievement (*27*).

Objective tests have been devised for several other traits: aggressiveness, recklessness, suggestibility. But all this work is rather in its beginnings (*19, 31*).

Imaginative responses. If we could induce an individual to give free rein to his imagination, expressing himself meanwhile so as to let us know what he is imagining, we should

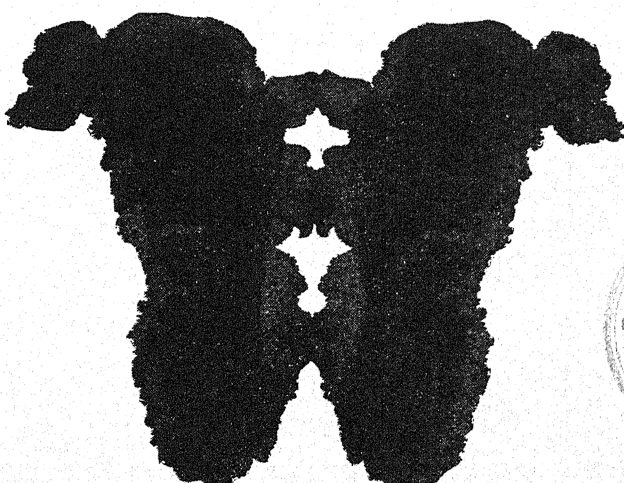

FIG. 20.–An inkblot (*not* one of the Rorschach series).

obtain some indications of his interests, preferences and emotional trends, as well as of his ability and experience. In short he might reveal his personality in free, unrestricted activity. Such is the hope behind a class of tests sometimes called the "fantasy tests." We might simply ask the subject to daydream and tell us his imaginings, but it will be better to give him some kind of a start. A story is begun for him

and he is asked to complete it. A picture is shown him and he is asked to weave a story around the picture. A cloud picture is shown him and he is asked to tell what he sees in the clouds. Most used is the inkblot. While the ink is still wet the paper is folded and pressed together so as to produce a symmetrical blot, often resembling a butterfly. A variety of things can be seen in such a blot.

If the psychologist is to obtain more than a very impressionistic view of the subject's mentality from the response to an inkblot, the responses of many persons must be compared, and some system of scoring must be worked out. Such standardization has been attempted by Rorschach and his followers. A collection of ten blots is used, some being plain black on white, and some in colors. They are blots in which most people will "see something." This standard set of blots is shown to the subject, one blot at a time, and he tells what he sees. He may see one thing after another. His responses are scored so as to answer such questions as these:

How often does he see human figures, how often animals, plants, landscapes, etc.?

Does he see the figure as a whole or fasten on details?

Is his impression governed by the form of the blot or by the colors?

How often does he see objects, especially human beings, in motion?

How good are the figures that he sees?

How original or unusual are his imaginings?

From these various scores taken together the Rorschach tester draws many surprising deductions. Seeing the blots as wholes indicates abstract and synthetic ability, while response to details indicates a preference for the concrete. Response to colors denotes impulsiveness, while seeing human forms in motion indicates a preference for inner thought. Seeing mostly animals denotes a stereotyped limitation of thought. Seeing good, clean-cut forms indicates good control. When all the indications are combined, the examiner may judge that a certain individual is "outwardly calm but

with dammed-up emotion, undergoing conflict but keeping himself well in hand, his productivity not up to his capacity." It seems too good to be true. Can these findings be valid? The best check on validity is to size up the subject's personality entirely from the Rorschach results and then to compare your finding with what is known of the individual from other sources. In some clinical cases this check has come out in favor of the method, but it would be premature to express a judgment, either favorable or unfavorable, on all the claims of the Rorschach testers (*3*).

SOME IMPORTANT PERSONALITY TRAITS

Among the dimensions suggested by the vast number of common trait names, a few have stood up well under intensive investigation and have some claim to be accepted. If not wholly separate they are at least not mere synonyms one of another.

Persistence, as against quick giving up and shifting to another activity, was already mentioned.

Trouble-finding, as against cheerful acceptance of the difficulties of life, is also called *emotional sensitivity*. It has a good claim to be regarded as a genuine dimension along which individuals differ.

Ascendance as against *submissiveness* has a good claim, though it may not be altogether separate from persistence and freedom from troubles. The ascendance-submission questionnaire contains questions like the following:

> Do you stand up for your rights on all occasions?
> Do you insist on good service from the tradesmen?
> Do you like to manage things and assume responsibility?
> Do you enjoy being host at a party?

The ascendant individual spontaneously takes the lead in any informal group, while the submissive one is the good listener and the good follower. The ascendant school child may be domineering, while the submissive one is characterized by

the teacher as agreeable, patient, willing, obedient (*1*, p. 40, *2*, *23*).

The introversion-extroversion complex of traits. For many years no traits attracted so much attention as this pair originally proposed by Jung (*16*). Extroversion, according to Jung's definition, consists primarily in interest directed toward the external world (including the world of people) and in finding the values of life in the external world; while introversion consists in finding interest and value primarily in one's own thoughts, feelings and ideals. The two interests are present in every normal person, and everyone shifts from one to the other. But some individuals, it may be, are *usually* interested in the immediate environment and deserve the name of extroverts, whereas individuals of the opposite tendency may be called introverts.

How would these tendencies manifest themselves? Jung and others worked out many ways in which introverts and extroverts could be distinguished. The extrovert would live in the present and value his possessions and social success, while the introvert would dream or plan for the future and value his own standards and sentiments. The extrovert would be interested in the visible, tangible world, while the introvert was interested in the underlying, invisible forces and laws of nature. The extrovert would be practical, the introvert speculative and imaginative. The extrovert would like action and would make decisions quickly and easily, while the introvert would prefer thought and planning and hesitate in reaching a final decision.

So far, the differences could be classed under *intellectual* introversion-extroversion. But questions like the following deal specifically with social life:

> Do you like to talk before a group of people?
> Do you always try to make others agree with you?
> Do you make friends easily?
> Are you at home among strangers?
> Do you like to take the lead in a social gathering?
> Do you worry over what people think of you?
> Are you somewhat suspicious of other people's motives?

Do you suffer from a feeling of inferiority?
Are you easily embarrassed?
Are your feelings easily hurt?

The "Yes" answer to the first five of these questions is supposed to be characteristic of the extrovert; to the last five, of the introvert. These questions refer to what might be called *social* introversion-extroversion.

The last five of these questions are also trouble items. There is an obvious overlap here between introversion and trouble-finding. Careful analysis indicates the presence of two dimensions here, one probably identical with trouble-finding or emotional sensitivity, while the other might be called *sociability* (*11*). Introversion combines and confuses three dimensions: liking for thought as against action, liking for solitude as against society, and proneness to find trouble in life.

There are then a few well-attested dimensions of personality, and there may be more, related to different human *needs*. Some students of personality speak of a large number of such needs (*20*, pp. 142-242). For example, there are the needs for security, for pleasure, and for achievement. Some individuals, because of their native constitution or because of their past experience, are especially anxious for security. Others think little of security but demand pleasure, others demand opportunity for achievement. The total personality must be very different according as one or another of these needs dominates the individual's feeling and behavior.

No bimodality here. However much we may like the extroversion-introversion distinction, we should not allow ourselves to fall into the habit of classifying everybody as either an extrovert or an introvert. Whenever any large sample of people has been examined by use of an appropriate questionnaire, they have been found to fall mostly along in the middle between the two extremes. A "mixed type," the ambivert, has been recognized (p. 66) and most individuals belong to this mixed type (*14*). In any dimension of personality, the mode lies near the middle between the extremes.

HOW CONSISTENT IS THE INDIVIDUAL IN HIS PERSONALITY TRAITS?

When we call a person a cheerful individual, we mean more than that he acts cheerfully in pleasant circumstances. We might allow him to lapse into gloom when everything was gloomy, but would insist on his being cheerful most of the time. Any such adjective applied to an individual implies that he behaves in a certain way with some consistency. But since the environment affecting him is anything but consistent, how can we expect consistency in his reactions?

As a matter of fact, almost no individual shows any specified trait with perfect consistency. No one gives all extrovert answers, or all introvert, in filling out a questionnaire. And when the same individual is observed day after day in a series of situations, as in a boys' camp (*21*), his behavior is found to veer sometimes toward the extrovert pole and sometimes toward the introvert. Behavior seems to depend on the situation fully as much as on the individual.

Two meanings of "consistency." We should distinguish (1) self-consistency from (2) trait generality. The meaning of self-consistency is easily understood. An individual is self-consistent if he always acts the same way in the same situation, even though in different situations he acts in surprisingly different ways. He is always even-tempered, let us say, except on one particular subject which never fails to get him angry. Well, he is perfectly consistent with himself. Another person shows a lack of self-consistency by behaving differently at one time and at another though the circumstances are the same.

Trait generality implies that a certain trait manifests itself in varied situations. If even temper were a perfectly general trait, the individual possessing this trait would show it under all conditions.

The distinction is clear in case of scholarship. If scholarship were a perfectly general trait, the student who gets *A* in one course would get the same in all courses (provided

the marking were accurate), and every other student would always get a certain mark. Such not being the case, we see that this trait lacks complete generality. But if a certain student always gets high marks in the languages but low marks in the sciences, he is perfectly consistent with himself. He is dependable, his future marks are predictable, once you know his pattern of scholarship. Here is another student whose marks vary in every subject; he shows little self-consistency.

Self-consistency and trait generality in respect to honesty. This distinction should be borne in mind in considering the results of an extensive study of school children, aged 8 to 15 years, in which use was made of the honesty tests already described (*13*). Each test in the battery yielded a "cheating score," ranging from zero when a child did no cheating up to a maximum when he took every chance to cheat. If the children's scores in two tests should correlate +1.00, that would mean that the child who did most cheating in one test did so in the other, and that every child similarly maintained the same position in the group from test to test. Now consider the actual results.

1. In the same test or practically identical tests, the correlation was high, but it became lower as the situations became more different. For example, there were several schoolroom tests in which cheating meant copying answers from a key; the correlation among these tests was +.70. There were several other tests in the gymnasium where cheating consisted in overstating one's performance; and the correlation among these tests was +.46. But the cross correlation between cheating in these two very different situations was only +.20. Cribbing in one test indicated that a child would probably crib in another test but afforded very little ground for predicting that he would overstate his gymnastic performance.

2. Of the individual children, some were much more consistent than others. Some were always honest but scarcely anyone was always dishonest. The most honest children were highly favored individuals, with high intelligence, good

homes and neighborhoods, and good emotional adjustment. The most dishonest (cheating) children were not especially low in intelligence but were not favored by home and neighborhood conditions.

3. Class units were more consistent than individuals. Even in the same town and neighborhood one schoolroom class sometimes stood out as definitely more honest than other classes. It was as if each class, perhaps largely from the teacher's influence, had developed its own code with regard to cheating.

Now as to the conclusions that can be drawn. The individual child was fairly consistent in the same situation; there was some self-consistency. But the correlations became moderate and then very low as the situations became more diverse; therefore the trait of honesty showed only a small degree of generality. Instead of speaking of dishonesty as a single trait one must specify the type of dishonesty and the type of situation, at least when speaking of school children. Cribbing in the schoolroom is one trait and cheating in a gymnastic contest is another trait only slightly related to the first. There may be a common factor present in all honest conduct, but it is cut across by other factors.

The fact that a minority of children were honest in all the tests suggests still another conclusion. Those children gave evidence of a general trait of honesty, while the children who cheated a great deal, not being consistent about it, gave no evidence for a general trait of dishonesty. Probably there is no such thing as a general "need for dishonesty." There are numerous temptations or incentives to cheat, lie or steal, and some incentives are stronger with one individual, some with another, but there is probably no natural propensity to be always dishonest, and there certainly is no ideal of consistent dishonesty held up to any child. It would be a very troublesome ideal to live up to—always to lie for the sake of lying, to cheat for the sake of cheating, to steal for the sake of stealing. But a general ideal of honesty is held up before some children and those who adopt this ideal will tend to be honest under the most varied conditions. Some

individuals—many of them in the aggregate—can be rightly described as thoroughly honest, but perhaps no one deserves the name of a thoroughly dishonest individual.

Social influences stand out clearly in the results, as would be expected in the case of honesty or dishonesty. Robinson Crusoe alone on his island could scarcely be either honest or dishonest. Whether such an act as appropriating a boat

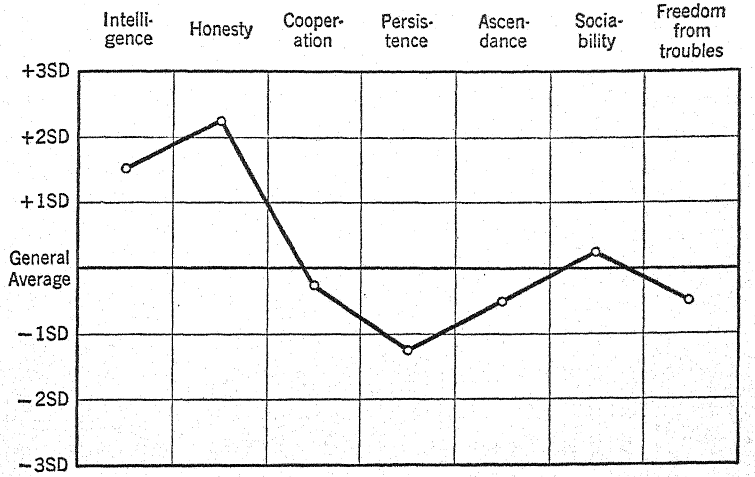

FIG. 21.—A personality profile.

or copying numbers from one sheet of paper to another is honest or dishonest depends on its social consequences and on the understanding among the persons concerned, on the group code, on the rules of the game.

Interaction between an individual's traits. When measures or ratings have been obtained on several traits of the same individual, they may be combined in a diagram known as the personality profile, which shows to the eye in what respects the individual stands high, low or average in comparison with the general run of people. His standing in each trait is indicated by a point suitably located above or below a middle line which represents the average of the population. The fact that this middle line is straight and horizontal does not mean that the average person is uniform in all respects,

but simply that the group average in every trait is taken as the standard or base from which to measure the individual. (The ordinate shows his *SD* score, p. 88.) If an individual should stand slightly above the average in every trait, his profile would be a horizontal line slightly above the middle line. The hypothetical individual whose profile is shown stands much higher in some traits than in others. The profile conveys an impression of the individual's high or low standing in general and of the evenness or unevenness of his personality. We cannot pretend that it pictures the "total personality," for it fails to show how the several traits *work together* in the individual's behavior.

A trait can be thought of as a behavior tendency. Sociability is a tendency to behave sociably, to seek company and to participate eagerly in group activities. Ascendance is a tendency to be masterful in any situation, whether involving other people or not. A person strong in both these traits would accordingly be a social leader, provided his other traits and abilities made him acceptable to the group. For another example, suppose a person to be strong in self-seeking but weak in energy. He would work when his own interests were directly involved, but in co-operative enterprises he would be a laggard. The individual's several traits, conceived as tendencies or forces, interact and are combined in his behavior.

The traits which we can analyze out of a total personality are not separate things or even separate tendencies. The laziness and selfishness of a certain individual are not two separate tendencies but are analyzed out of behavior which is limited to getting everything possible for the self with the least expenditure of effort. The traits pictured in a profile may seem unrelated and even incongruous, but if we observe how they express themselves in the individual we can usually see that they work together in harmony so that the individual has an integrated personality. After we have picked a personality to pieces, tested and rated him in various dimensions in comparison with other people, we need to go back

to our individual and envisage him as a living, unique person (*1*, pp. 343-365).

Multiple personality. Though the individual is an integral whole, he may lack something of perfect integration. All of us are inconsistent in the sense that we pass back and forth between different states or activities in which our behavior is quite different. In one state we are energetic, in another state sluggish; in one state we are responsive to the environment, in another state very much withdrawn; in one state we are wide awake, in another state fast asleep. We behave differently when hungry and when well fed, when in a hurry and when at our ease. Human personality is a many-sided affair, and different sides become prominent in different states and activities. Our desires pull us in different directions, our interests are not easily integrated into a single all-inclusive purpose in life. Some individuals are relatively well integrated, while others appear distracted and unstable.

Disintegration appears with dramatic vividness in those rare cases (*18*) that go under the name of double personality. The individual passes from one state to another, showing very different tendencies in the two states, and forgetting in the primary or more lasting state everything he has done in the secondary state. In the secondary state he generally remembers the primary state but speaks of it as belonging to another person. The primary state is somewhat abnormal or limited, as if the individual were not his complete self, while the secondary state is a sort of complement to the primary, though very incomplete in itself. An individual who in the primary state is excessively quiet and submissive will be excessively mischievous in the secondary state. He seems to live in fractions and never as a whole.

In the celebrated Doris case (*26*) a little girl at the age of three years was thrown to the floor by a drunken father angry at finding her asleep in his place in the marital bed. From that moment she became an extremely quiet, industrious and conscientious child, except for intervals when she was wild and mischievous. The sober Doris had no memory of the pranks

of the mischievous Doris, though the latter knew all about the former and spoke of her with scorn. The still more celebrated Beauchamp case (*25*) was that of a young woman whose difficult early life caused her to adopt an extremely religious, conscientious and self-effacing attitude, but who had brief, unaccountable episodes of mischievous conduct. In the psychotherapist's hands her mischievous side took shape in a secondary childish state, and a third personality emerged with normally aggressive and self-seeking tendencies. The primary, self-effacing state had no memory of what happened during either the self-seeking or the childishly mischievous state. The case thus developed under treatment into one of triple rather than double personality. The psychotherapist attempted to assemble these three fractions into a complete person, and apparently succeeded after years of effort. His chief method was to put the subject into the passive, suggestible state known as hypnosis, in which she could remember all three of her alternating states, and then to suggest that she would awake from hypnosis with all her memories retained. In the case of an ex-soldier whose split personality resulted from war strain, the separate memories were brought together by recall of certain events which served as bridges between the two states (*9*). Whether the essential achievement in these cases is the integration of the subject's memories, or the integration of goals and tendencies, is still open to question.

Summary of the chapter. The question has been how to judge personality. Those who are professionally concerned in judging personality seek to be as objective as possible, and depend largely on the interview and the inclusive procedure known as the case study. In trying to analyze personality into traits or dimensions, psychologists use such devices as the rating scale, the questionnaire, and performance tests—all of which have their limitations. Certain traits—persistence, ascendance-submission, trouble-finding, and extroversion-introversion—stand up pretty well, though the last-mentioned should probably be broken up into three traits. No excuse

has been found for dividing mankind into opposed types, as most people fall near the middle of any dimension of personality. These traits do not show great generality, though the individual may be self-consistent to quite a degree. In exceptional cases we find the high degree of inconsistency known as double or multiple personality.

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Chapter VI

Physiological and Social Factors in Personality

IN ORDER to approach an answer to the problem of control and improvement of personality—whether the personality to be improved is one's own, that of one's children and other charges, or that of people in general—it is necessary to have some knowledge of cause and effect in this field. It is necessary to look into the factors that produce individual differences in personality, and to see what experiment and practical experience have revealed as to ways of changing personality. Though each individual is in a sense unique, each is not "a law unto himself." The same causal laws operate in all people, even in the most eccentric and abnormal. If there were no general laws of personality, the task of the psychological adviser would be hopeless. He must apply to one individual what he has learned from the study of other individuals and what he knows of the organism and its relations with the environment.

Physiological and social psychology meet in the study of personality. Their meeting sometimes has the appearance of a battle, with one side shouting for the biological factors, the other for the social factors. Some will tell us that personality depends on "the glands," others that it depends on social influences. We will listen to both sides, beginning with the physiological.

The individual's *physique* is certainly a factor in his personality. The mere size of a person affects his attitude toward other people and their attitude toward him, though the

big fellow is not always inclined to be dominant nor the little one to be submissive. Muscular development and "looks" also have their effect.

Another biological factor may be spoken of as the

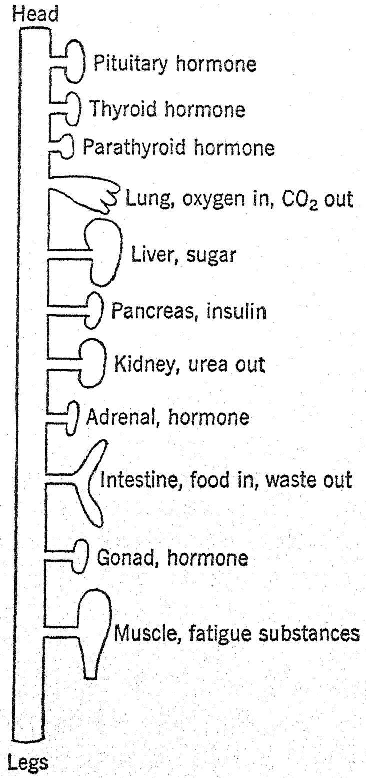

FIG. 22.—Organs contributing substances to the blood stream.

chemique of the individual. It corresponds to what the ancients called *temperament*. They attempted to connect the "four temperaments" with four important "humors" of the body. The sanguine individual, they said, had a surplus of blood, the choleric a surplus of bile, the phlegmatic a surplus of phlegm, and the melancholic a surplus of spleen. Sometimes a fifth temperament, the nervous, was admitted, resulting from a surplus of the "nerve fluid."

Though this particular physiological theory is out of date,

the possibility remains that chemical substances carried in the blood have much to do with the quality of one's behavior. Some of these chemical substances are introduced from outside in food and drink or through infections. The presence of alcohol in the blood certainly alters many a person's "temperament" for the time being; and the absence of vitamins from the food and therefore from the blood leads to languor or to nervous irritability. Dearth of oxygen, as at great altitudes, has a pronounced effect. These substances come from outside; but there are also chemical substances manufactured in the body and carried around by the blood which have marked effects on growth and behavior.

The blood stream as the chemical integrator of the organism. The chemical factors in personality are dependent on the circulation. No less than the nervous system though in a very different way, the circulation is an integrator of the organism. The circulation is like a railroad in carrying substances; the nervous system is like the telegraph and telephone in carrying messages; but neither of them operates much like any man-made system. The transportation of substances proceeds in this way: each organ delivers its output of substances into the blood; driven by the heart, the blood circulates through all the organs, and each organ helps itself to substances as they stream past. The circulation is surprisingly rapid; it may take only fifteen seconds for a substance delivered into the blood stream by one organ to reach all the organs. The activity of the muscles or of the brain can be affected very quickly by substances discharged into the blood by the glands or other organs.

THE ENDOCRINE GLANDS

An endocrine gland, or gland of "internal secretion," is one that delivers its product to the blood. It produces one or more *hormones*, substances having the power to raise or lower the activity level of the body or of certain organs. For example, the pancreas produces two secretions. One, the well-known pancreatic juice, is not an internal

secretion because it passes from the gland not into the blood but into the intestine, where it acts on the food and plays an important part in digestion. But the pancreas also discharges into the blood a substance called *insulin.* This hormone, being carried by the blood to the muscles, enables them to use sugar as a fuel, i.e., to burn or oxidize sugar. If the pancreas fails to produce insulin, the organism lapses into the condition of diabetes in which the sugar, not being oxidized, accumulates in the blood till removed by the kidneys. Variations in the output of insulin cause variations in the individual's activity and feelings. An excess of insulin makes him feel hungry, fatigued, tremulous and anxious; a still greater excess produces severe mental distress and eventually delirium and unconsciousness. (The mental state is affected also by deficiency of this hormone.)

In general, the endocrine glands are small organs and not at all important in appearance, but, from about 1850 on, physiology and clinical medicine, between them, have been building up an extensive science of endocrinology and have found these little chemical factories to be of vital importance. The physiologists work on animals by two main methods: by removing a gland and noting the effects of the loss on the animal's growth, health and behavior; and by replacing the gland or supplying the hormone by the mouth or by injection. The clinicians take note of diseases resulting from overactivity and underactivity of the glands and treat them by glandular extracts, following the leads discovered in animal experiments. Chemists are playing their part by isolating from the glands the chemical substances which actually do the work. Some of these hormones can now be produced synthetically in the chemical laboratory.

The thyroid gland. This lies at the base of the neck in front of the windpipe and normally weighs less than an ounce. Its enlargement into a "goiter" may or may not indicate anything seriously wrong. When this gland is destroyed by disease, the individual loses his former vim and alertness and sinks into a sluggish condition known as "myxedema." The skin is puffy. The muscles and brain

are inert. The individual is slow, stupid, forgetful and unable to concentrate or to think and act effectively. If the gland is defective from birth or is lost in childhood, growth is stunted and intelligence does not develop. In the worst cases, called "cretins," the individual remains a dwarf, misshapen and imbecile, though placid in disposition.

One of the dramatic discoveries of endocrinology was the

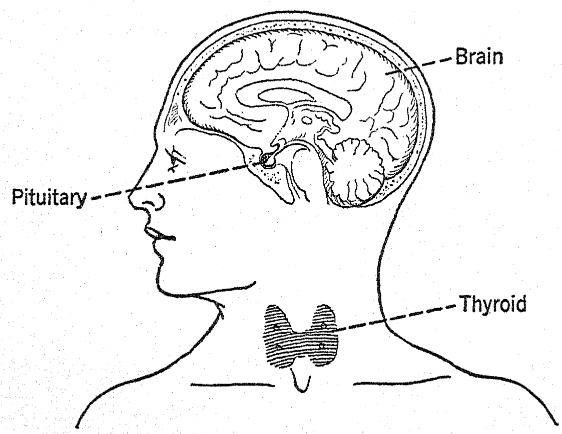

FIG. 23.—Locations of the pituitary and thyroid glands. For another view of the pituitary, see p. 264.

cure for myxedema. It was found that simply feeding sheep's thyroid quickly restored the normal state, as if by magic. An extract of the gland can be taken with the same results. The cure does not, to be sure, develop new thyroid glands in the patient, but so long as he continues to receive adequate doses of the thyroid substance his condition remains normal. Even the poor little cretins can be helped if the use of thyroid substance is begun early enough. Their IQ can be brought up to 60, which is far above the level of the untreated cretin.

The thyroid hormone, called *thyroxin*, has been chemically analyzed and found to have a composition indicated by the formula, $C_{15}H_{11}O_4NI_4$. The carbon, hydrogen, oxygen and nitrogen in this formula are the commonest chemical elements in the body, while the iodin is almost peculiar to

thyroxin. The iodin taken into the body in food and drinking water, in very small amounts, is concentrated by the thyroid gland into this chemical compound.

In regions where the iodin has almost all been leached from the ground and carried down to the sea—as in Switzerland and the Great Lakes region of North America—the task of the thyroid gland is made doubly hard by the scarcity of iodin taken in. Thyroid deficiency is common in these regions but can be forestalled by iodizing the table salt.

The primary work of thyroxin is to speed up the "metabolism" or chemical activity of the body, especially the process of oxidation. When this hormone is deficient in amount, metabolism sinks to a low level; little oxygen is consumed and little carbon dioxide given off. When the thyroid produces an excess of the hormone, the rate of metabolism is raised above normal.

The rate of the "basal metabolism" is an indicator of thyroid output. Basal metabolism is the oxidation that goes on in an individual who is as completely inactive and relaxed as he can be while awake. It corresponds somewhat to the consumption of gas while the automobile engine is "idling." Some metabolism is of course necessary to provide for such continuing activities as breathing, the heart beat and the maintenance of body temperature. The rate depends on the size of the body and the total area of the skin, through which heat is constantly escaping, but it depends on the thyroid, too. An individual whose basal metabolic rate is to be measured is taken before breakfast (so that no active digestion shall be going on), made to lie on a cot (to minimize muscular activity), and instructed to relax and not to worry about anything. A gas mask is adjusted over his face with an intake tube bringing him fresh air, and an outlet tube carrying his expired air off into containers so that it can be measured and analyzed. Thus his consumption of oxygen during a certain time is measured. Individuals differ in basal metabolic rate, most of them falling, however, between 90 and 110 percent of the general average or norm; but the thyroid cases show great divergence from

the norm, down to 60 percent in some cases of myxedema and up to 160 percent in some cases of overactive thyroid (*5*).

When the thyroid is greatly overactive the individual is restless, tense, irritable, worried, unstable. If he is still in the growing period, his growth is rapid, especially in length, and he becomes, physically, just the opposite of the cretin dwarf. It does not appear, however, that his mental growth is accelerated or his intelligence raised.

Besides the extreme cases of thyroid excess or deficiency, there are probably many cases deviating moderately up or down from the norm. Individuals differ in their basal metabolic rate. As far as known, there is only a slight correlation between this b.m. rate and intelligence, but there is some evidence that children's school achievement may drop below their intelligence level because of the apathy induced by moderate thyroid deficiency and indicated by a low basal metabolism (*28*). Personality differences in the dimension of overactivity and underactivity are sometimes due to the thyroid, but can also result from other causes. A diagnosis of thyroid abnormality cannot be made from personality traits alone.

The parathyroids. When disease of the thyroid necessitates its removal, the surgeon takes great care not to disturb the four tiny parathyroids lying close to the thyroid. If they are removed, the patient goes into a tense, overexcitable state, with painful muscular cramps. This dangerous condition is relieved by injecting parathyroid extract. The nervous system is overexcitable in the *absence* of the parathyroid hormone which in contrast to the thyroid is a quieter rather than an exciter. Excess of the parathyroid hormone brings on an excessively quiet state with flabby muscles and general lassitude. Pronounced cases of parathyroid excess or deficiency are rare.

The adrenal glands. These little glands were named from their location close to the kidneys, though they are quite distinct from the kidneys in function. Each adrenal consists of an outer part called the cortex (bark) and an inner part

called the medulla (pith or marrow). The two parts differ in structure and function, and each is an endocrine gland in its own right. The hormone produced by the medulla is *adrenin;* that produced by the cortex is *cortin.*

Adrenin is a powerful hormone, very small quantities in the blood being sufficient to produce the following effects:

Strong, rapid heart beat
High blood pressure, forcing blood predominantly through the muscles and the brain, rather than through the skin or viscera
Suspended activity of stomach and intestines
Wide opening of the air passages in the lungs
Release of stored sugar from the liver
Delay of muscular fatigue
Free perspiration
Dilation of the pupil of the eye

These effects are also produced by activity of the "sympathetic division of the autonomic nervous system" (p. 426). The sympathetic nerves produce these results quickly and for short periods of time, while adrenin, discharged from the gland into the blood, gives the same results more slowly but for longer periods. Thus the adrenal medulla is an adjunct of the sympathetic nerves.

Is there any coherence among the varied effects listed above? Cannon (*3*) has shown that all these changes occur in an animal getting ready for a fight and that they serve to mobilize the animal's forces to meet a sudden emergency.

Cortin is required for long-continued muscular exertion, and also for resisting infection and other threatened damage to the organism. It tones up the organism in some way that is not yet perfectly clear. It is necessary for life. Complete destruction of the adrenal cortex in man, usually by tuberculosis, results in a fatal disease named, after its discoverer (1855), Addison's disease. The symptoms are: progressive weakness and lassitude, loss of sex interest, low basal metabolism, and low resistance to any infectious disease. The skin darkens; the patient cannot endure heat or cold; he suffers from insomnia. His behavior is marked by poor judgment,

irritability and lack of co-operation. These symptoms are removed by administration of cortin.

Overactivity of the adrenal cortex seems to be one cause of an excess of masculine characteristics in either man or woman. In a woman it causes loss of the rounded feminine contours, deepening of the voice and growth of a beard.

The gonads. The primary sex organs, female ovary and male testis, besides producing the reproductive cells (ovum and spermatozoon, p. 199), also secrete hormones that have important effects on growth and behavior. There are several of these hormones and some of them are present in both male and female. A balance of male hormones steers development in the direction of masculinity, a balance of female hormones steers it toward femininity. At puberty these sex hormones promote the development of the genital organs and of such sex characteristics as the mammary glands of women and the beard and deep voice of men. Lacking the gonads, the individual of either sex develops into rather a neutral specimen without strong sex characteristics.

The internal reproductive processes in the female, including the menstrual or estral cycle, pregnancy and lactation, are controlled very largely by hormones. Even the urge to give maternal care to the infant seems, in animals at least, to depend on hormones, but the efficiency of maternal behavior depends on the brain (*2, 14*).

Sex behavior is simpler and better studied in animals than in man, and the results are clearer in the female than in the male animal. Each estral cycle in the female includes a comparatively brief period of readiness for sex activity and a longer period of sex inactivity. In the active period an egg or ovum is discharged from the ovary toward the womb, ready for fertilization. The animal's external behavior during the active period is peculiar in two respects: she shows much more general motor activity than at other times, and she shows special sex activity. Her response to the male animal is very different in the active and inactive periods. During the inactive period she fights off any male that makes advances to her, but during the active period she is receptive

and co-operative. The male animal shows no hormone cycle but is much more aggressive toward the female after a period of sex deprivation than soon after free sex activity.

In the human species the same hormones are demonstrably at work but the picture is complicated and diversified by mental and social factors. The sex hormones, though present in childhood, increase during adolescence and are certainly necessary for the development of sex interest. As to personality traits, some individuals appear to be oversexed and others undersexed. Such differences may be due to the hormones, though real evidence on this point is scanty. Some individuals who lack the normal amount of spontaneous sex interest are criticized by their associates and react by engaging in sex activities, usually of some peculiar sort. Other individuals with normal hormones are driven into atypical sex attitudes by peculiarities of their social environment. The individual's sex behavior is determined by three general factors: his spontaneous sex interest, dependent on the hormones; the opportunities and restrictions of the environment; and his other interests which compete or combine with the sex interest.

The pituitary gland. This is called the "master gland" because of the control its hormones exert on the other endocrine glands. The pituitary is a small body attached to the under side of the brain. It can be seen in Fig. 23, p. 172. Part of it, the posterior lobe, originates as an outgrowth of the brain, while the anterior lobe develops from the mouth region of the embryo. The pituitary is probably subject to direct influences from the brain. The anterior lobe supplies hormones that stimulate the thyroid, the gonads, the adrenal cortex and perhaps other glands; and without the pituitary hormones these glands do not develop and function normally.

The anterior pituitary also has great influence on bodily growth. If this gland is overactive in childhood, the bones and muscles grow rapidly and the individual may become a veritable giant, seven to nine feet tall. The gland, after this period of overactivity, is likely to become exhausted with the result that the giant loses muscular strength and dies young.

If this same gland, after being just normally active during the growth period, becomes overactive during adult life, the individual, without growing any taller, develops large hands, feet, nose, lower jaw, etc.—a condition known as acromegaly (meaning "big extremities"). Underactivity of the anterior pituitary during the growth period is known to produce dwarfs of a symmetrical type, "midgets," who are quite different from cretins, being often rather attractive in appearance and normal in intelligence. While they are still young their growth can be increased by pituitary extracts.

Endocrine balance. The relation of the pituitary to behavior and personality is very difficult to discover, partly because this gland works so largely by stimulating other glands. Endocrinologists are convinced that moderate overactivity of the pituitary makes the individual muscular, aggressive, self-controlled and calculating, while underactivity of this gland produces muscular weakness, sluggishness, easy discouragement and a tendency to give up and cry. These states of the organism may be produced, however, not by excess or deficiency in the pituitary hormones alone but by a lack of proper *balance* of all the hormones. Diagnosis of a particular endocrine disturbance is scarcely possible from the individual's behavior alone. For the same reason it would be useless for anyone to attempt to analyze his own personality in endocrine terms and then to try to improve it by glandular treatment.

Another complicating factor is the subject's *reaction* to the comments of his associates on his condition. Thyroid deficiency tends to sluggishness, but if the subject is constantly criticized for his sluggishness he may develop an irritable behavior quite different from what one would expect from the thyroid deficiency alone. Lack of gonadal hormones naturally leads to lack of sex interest, but the subject's reaction, as already stated, may lead him into some atypical form of sex behavior. Some endocrine imbalance may make an adolescent drowsy and unable to concentrate, while his appetite is enormous and he lays on great quantities of fat. Much comment is sure to arise and his reaction may be to

withdraw from society, or to be sullen and resentful against authority, or to acquire the habit of stealing to satisfy an appetite for sweets (*17*).

The endocrine balance of most people is probably about normal. Out of 650 young persons referred to an endocrinologist "because of outward evidences suggesting endocrine disorders," only 374, or 58 percent, revealed any such disorder on careful examination. There were 279 cases of trouble originating in the pituitary, 79 of thyroid trouble, and 16 of underactivity of the gonads (*23*). In the population at large the proportion of true endocrine cases would obviously be very much smaller than in this suspected group. Enthusiastic endocrinologists have sometimes overemphasized the importance of the hormones as determiners of individual differences in personality. Of course we all need the hormones to have any vim, any calm control, any life at all; but if most of us have nearly the same hormone balance, our differences in personality must be laid to other causes. Some of these other causes are biological and some social. The best we can say is that the endocrines are among the basic biological factors in personality (*10*).

SOCIAL FACTORS IN PERSONALITY

That fundamental principle of psychology, to see the individual in his environment, is nowhere more important than in tracing the development of a personality. Like ability, personality is developed by the individual's activity, and activity depends on stimuli received from the environment as well as on the individual himself. There is no reason for laying all our emphasis on the *social* environment. A tropical climate may foster an easy-going disposition, and the wide open spaces of some regions, with the whole country always spread out before one's eyes, may foster an inclination to look at things in a large way. Such possibilities have not received the scientific study that they deserve, but much attention is being directed to the influence of the social environment upon personality.

The words *code* and *role* suggest two important influences of the social environment. The individual builds up a code of conduct. He adopts the code of his group or at least builds up his personal code in living with the group; and he finds or makes a role for himself in the group.

Acquiring the group code. Any social group seeks to enforce certain rules of conduct on its members. The group code covers manners as well as morals. It comprises the "mores" or folkways and differs greatly from tribe to tribe, from family to family, from gang to gang. The child picks up many of these rules easily and cheerfully, and where he resists he is subjected to criticism, ridicule, punishment or ostracism, until he conforms. He usually ends by adopting the group standards of behavior.

Besides its rules of morals and manners, any group has more subtle nuances of behavior which come closer to personality traits. Just as one picks up the dialect of a place, with its drawl or twang or "Oxford accent," so one takes on the local *style* of behavior. This kind of social influence is well brought out by studies of isolated communities. One small mountain community, back in the forests of the Blue Ridge, without even a wagon road from outside, had lived and inbred for a hundred years with scarcely a thought for the progress of national events. There was little traffic in or out, and those who went out and tried town life sometimes came back with relief because they could live with less effort in the mountains, and could "get up when they pleased and dress as they pleased." The tone of the community was easy-going, unambitious, fatalistic, and such was the tone of the individuals. It seems a clear case of the individual's taking up personality traits from the environment. But we must not overdraw the picture. Even in this community the individuals differed. There was a steady, industrious man, there was a relatively enterprising man, there was a boy ambitious to succeed in the world, there was at least one young woman who repudiated the local fatalism in respect to every woman's predestined large family of children. Here we see the individual more or less successfully *resisting* the social

environment, and we learn that personality is not forced on the individual. It is his reaction to the environment and depends on his individual organism as well as on the environment (*25*).

There are "black sheep" in every group, deviates from the standard behavior of the group. Those who deviate too much are suppressed, but some latitude for deviation is probably always allowed, though some groups are much stricter than others in enforcing conformity. Because codes differ greatly from group to group, an individual who is a misfit in one might be quite at home in another. Some groups are openly and blatantly competitive, so much so that an individual who surpasses others in wealth or prowess is expected to boast openly of his superiority. Other groups, if competitive at all, are much more subtle about it; an individual can win social approval and praise, but he does so by service and modesty. Our own culture is highly complex in this regard. We enjoy competition, for example in games, but it runs to teamwork and rivalry between sub-groups, and boasting of personal success or sulking under defeat is decidedly bad form. Being a misfit in one's group tends to create a personality difficulty, sometimes of the rebellious sort, sometimes of the shrinking and neurotic sort. A person may become a misfit on moving from one community to another where the style of life is very different, as happens sometimes to immigrants. Or a person may be a misfit because his natural inclinations conflict with the group standards. Personality difficulties are thus sometimes the result of a disharmony between the individual and the group. Undoubtedly some personality difficulties have nothing in particular to do with the group but result simply from internal conditions such as thyroid deficiency. The causes of the neuroses and insanities are not thoroughly worked out but we should have our eyes open for both organic and social factors.

Acquiring the group code in childhood. Any group game affords a concrete instance of a code which must be obeyed if the game is to run smoothly. A study of Swiss boys (*21*)

traced the gradual development of their grasp of the rules of the game of marbles. The experimenter had boys play the game before him and quizzed them on the rules. The very youngest children need no rules, as each child plays entirely by himself. Somewhat older boys follow some rules in a lax way, but have no great need of them because they are not definitely competing. Each boy is simply trying to make his marble hit the marbles in the "square" and both players can win the same game. Only later does the real competitive game appear, with its numerous rules, the purpose of which is apparently to put a premium on skill and to magnify the social aspect of the game.

When first learned by the younger boys, the rules are regarded as sacred and authoritative. Each little boy is likely to say that his father invented the game and established its rules. The older boys are fully aware that the rules exist simply to insure a good game and could be changed by common consent of the players, provided the game would be improved. Probably few adults understand the true nature of their own group code as well as boys of twelve or thirteen see around their game of marbles.

The Swiss investigator inquired into children's ideas regarding lying; he asked them what lying is, why it is bad, and which of two suggested lies would be worse. The six-year-olds defined lying as "saying naughty words" and explained that lying was bad because it was punished. They thought it not very bad to tell a lie to a child, "because the child will believe you." A child who falsely reported to his mother that the teacher had given him a good mark in school did not lie, for his mother believed him and gave him a cookie; but a boy who told the assembled family of seeing a dog as big as a cow told a very bad lie because no one believed him.

The children of eight to ten years have completely changed their ideas. To them a lie is a statement that deceives someone. It is worse to lie to a child than to a grown-up because the child will believe you. Lies are bad "because if everyone lied no one would know where he

was." Thus, with the older children, lying no less than the rules of a game is evaluated according to its social effects.

The logic of the younger child, who thinks a lie is bad because it is punished, may seem perverted, but it is perfectly good from the child's standpoint. He has to discover the code by trying out various acts and seeing which are acceptable to his elders. When he thus discovers a rule of conduct, it is sanctioned by adult authority and not by any known social utility. Exactly how he advances from the authoritarian to the utilitarian conception of rules we do not know.

Finding a role for oneself. However rigid a group code may be it at least must allow for a variety of individual roles. Each person has his own particular role to play. To some extent the available roles are determined by group organization. There must be a provider, there must perhaps be a leader, and it is nice to have an entertainer. If all individuals were potentially alike, the roles might be distributed at random, and then each individual in filling his assigned role would develop the potentialities appropriate to that role. According to his role he would develop different traits of personality. The provider would become provident, the leader would become ascendant, the entertainer would become entertaining. Personality, from an ultra-social point of view, is the individual's response to the role imposed on him by the group. To a student of individual differences it would seem more likely that each individual gravitates toward a role that suits his own characteristics, and that he finds his role or makes it rather than having it thrust upon him by arbitrary group action. Once in a role he certainly develops according to the requirements and opportunities of that role. The personality of an adult would then depend partly on the roles he has filled and partly on his inherent characteristics, the social and the individual factors working together at every stage of his development.

The role of the child in the home. Because of his inherent characteristics as a child, the individual's first social role is to be weak and dependent but also to grow and become more

and more independent. His role is anything but static and he comes to feel, himself, that the main thing for a child to do is to grow up. His role is also to be loved and admired. But the exact nature of a given child's role depends very much on the parents—not entirely, for each child early shows characteristics that have to be reckoned with by the rest of the family. Some parents do not give the child half a chance to grow up. Children come to the behavior clinics suffering from personality difficulties which are the result of injudicious handling by their parents. In one family the parents are so solicitous to protect the child from every danger and hardship that they prevent his learning to do anything for himself, while in another family the child is held in such rigid subjection that he, too, remains overdependent. The spoiled child and the cowed child in their different ways show personality traits due to the roles imposed on them at home (*22*). The favorite child, too, and the unwanted child are given roles in the home which have an effect on personality.

With two children in the family the home environment is not the same for both. Even if the parents treat them the same, each one has a different child for companion. The older of two brothers has a younger brother as part of his environment, while the younger has an older brother—quite a different thing. Some psychologists, especially Alfred Adler, have laid great stress on the child's family position or *birth order*. The only child, never supplanted, never having to share, might well become overdependent and at the same time tyrannical. The oldest child, after playing the role of the only child for a few formative years, is deposed; we might expect him to become a jealous person, striving to keep what he has, believing in authority and privilege. The second child is always trying to catch up and might become an especially eager person and a rebel against the established order. The youngest child, as the perpetual baby, might permanently cling to the role of everybody's pet who always looks to others for help. Except in large

families, it would seem, every child is cast for an unfortunate role (*1*).

Investigators in the behavior clinics have attempted to verify these suggestions regarding birth order but with little success. On the whole, no position in the family comes out worse than any other. The same kinds of personality difficulty are found in children of every position, and with about equal frequency. The only child is not as a matter of record unduly represented among the problem children referred to behavior clinics, and he presents no peculiar type of behavior difficulties but shows the same variety of problems as other children. Among university students the "trouble score" (p. 149) is not larger on the average for only children than for others, nor does it show any consistent relation to the birth order (*12*). The clinical psychologist regards the child's birth order as a fact worth knowing because it suggests what his difficulties *may be*, but it is no sure indicator of what his difficulties actually are. Too much depends on the atmosphere of the home, and too much depends on the inherent characteristics of the individual child.

Adler, to do him justice, fully recognized the importance of other factors in the home besides birth order. Much depends on the mother's skill in initiating the child into group life and helping him to develop a social disposition, an understanding of other people and a willingness to give and take and to become a participating member of the group, a social being. Even if he adopts this desirable general role, each child specializes his own role according to his early experiences. The spoiled child expects always to be the center of attention, while the rejected child adopts the attitude of keeping at a safe distance. So every child, according to Adler, develops in his first few years a "style of life" which remains fundamentally unchanged for the rest of his life.

Freud and his followers, the psychoanalysts, have contributed to our understanding of the child's role and code the concept of *identification.* The child imitates his elders, not passively but intentionally and eagerly. He wants to be like his father, or she wants to be like her mother—some-

times the other way around. Freud himself gave a curiously indirect explanation of the source of this tendency of the little child to identify himself with one of the parents. Normally, he said, the baby boy has first a possessive love-attitude toward his mother. When his mother shows affection for his father, he is jealous and feels his father to be a rival. Being unable to put his father out of the way, and also feeling some love and admiration for his father, the boy seeks to assimilate his own role to that of his father and so to identify himself with the father, adopting the father's behavior as his own standard of conduct. Such is the origin, according to Freud, of the individual's personal code, that is to say, of his conscience. This code is adopted not deliberately but impulsively and being thus more or less irrational it is likely to conflict with the realities of life and to lead to quite unnecessary feelings of guilt.

The little girl, we might expect, would identify herself with the mother and show the same effects with the sexes reversed. But the mother's relation to both boy and girl is so much the same, at the outset of the child's life, that the theory does not work out so neatly in the girl's case. Perhaps it is just as well, for the theory is really too neat, and largely imaginative and spurious.

We need not accept Freud's elaborate theory in order to believe that the boy does identify himself with the father. The father has the prestige of bigness and strength, he shows affection for the boy and usually has the advantage of being held up by the mother as a fine being. On the other side the father may be stern at times, he may be delegated to do the severe punishing, and so he comes to represent the disagreeable factor of *authority* which the child tends to resist. The child's attitude toward his father thus contains contradictory elements, but the contradiction is resolved by identifying himself with the father. The code so adopted need not be irrational and unrealistic, even though it is authoritarian rather than utilitarian at the outset.

Freud and Adler agree in tracing the individual's fundamental role in life back to the family situation in the very

early years. They are one-sided in discounting the social influences affecting the child and youth from outside the home. They regard the effect of these later influences as being superficial and not reaching to the heart of the personality, which they believe to become fixed in early childhood. Their evidence, drawn from the study of adult neurotic individuals, is inconclusive because these individuals seem to be those who have not grown up in personality. Most people, we may believe, are more flexible, more responsive as children to influences from the school and playground, and as young adults to the larger social group. Development is of course a continuous process, with no sharp break between babyhood and adulthood, and yet the child's attitudes and style of life may be profoundly modified as he participates in the varied activities of community life.

The child's role in the gang. The study of play groups is a valuable lead in social psychology and in tracing the development of the individual's personality. In spite of the importance of the home environment in fixing the individual's traits, the child often takes more interest in his playmates and may find his role and adopt his code in the play group more than in the home situation. Among his fellows he escapes from the role of a dependent and has scope for his love of adventure. Whether adventure shall mean lawlessness depends largely on the facilities and standards of the neighborhood. Boys' gangs often have a leader and an inner circle, regular members and hangers-on. The activities of the gang provide a framework in which the individual boy finds his place. One boy may be the "brains" of the gang, one the dare-devil, and one the funny boy. One may serve as the "goat" or the cat's-paw. The more desirable roles are won by competition. In a fighting gang the leader has to prove himself the best fighter. Personal traits such as generosity count heavily in winning the important roles. The roles are not handed out at random but are determined in large measure by the existing traits of each boy. Therefore we cannot say that the role makes the boy, though we must

agree that the boy who has found a congenial role develops his personality according to his role (*24, 26*).

We should know much more than we do of the changes in personality that occur in adolescence. We know from studies already made that play groups in early adolescence show a rather sudden shift of interest to dancing and other forms of companionship between the sexes—a shift that occurs about two years earlier in girls than in boys, in conformity with the earlier puberty of girls, and that seems therefore to depend on physiological factors. At this period there is a rapid loss of interest in marbles, stilts, kites and other favored games of childhood, and a loss of enthusiasm for some spectacular roles in life, like those of the cowboy and circus performer, which greatly appeal to children (*6, 16*). The "storm and stress" traditionally supposed to characterize the period of adolescence is by no means always present even in our own culture, and seems to be quite absent from certain other, freer cultures (*18*). But the "growing-up impulse" of childhood is accentuated in adolescence with an active search for individual roles in the world's work and social life (*27*).

IMPROVING PERSONALITY

This is a big subject and there is little of a scientific nature to say on such questions as how to develop good qualities like sympathy and frankness, or how to eradicate excessive tenseness and touchiness. It is dangerous to hand out general rules and maxims, for the persons who take them most to heart may be the very ones who would profit by just the opposite advice. For example, frankness is certainly a desirable trait, and a freely but unemotionally expressed objection to some irritating behavior of your friend may prevent the building up in you of suppressed irritation till it reaches the bursting point and explodes in a serious quarrel. But the person who takes this rule to heart and continually nags his friend builds up irritation in the friend or drives him

away altogether. "Grin and bear it" would be a better rule for some persons and some situations than "Be frank."

Ascendance and submission are a pair of traits, neither of which should be developed to excess. The person who always wants to dominate and is never willing to follow a leader makes an undesirable companion; so does the person who will never take the lead nor stand up for his rights. How do these opposite traits develop? Judging from a study of college girls, the most dominant ones have had a large degree of independence as children and have sought satisfaction in achievement rather than in being good or in being admired (*4*). We cannot be sure that the family situation was entirely responsible, for some children, more than others, insist on independence and active achievement.

An experiment in training for ascendance. Nursery children were the subjects in this experiment, and they are probably the best subjects for experiments in changing personality traits, being less self-conscious and wary than older persons would be. The shyest, least ascendant children in a class of four-year-olds were given certain training after which their ascendance score rose considerably. The experiment included a fore-test, a training period, and an after-test. In the fore-test, each child was placed with another child to play in a sand box while the experimenter watched from behind a screen and noted down the child's attempts to secure play materials by verbal or forcible means, his efforts to lead and direct the other child, his success in these efforts and his compliance with the demands of the other child. The children who made very low ascendance scores in the fore-test were then trained by the experimenter till they had complete mastery of certain play materials—blocks for building certain designs, a jigsaw puzzle, a picture book with its story—and then each trained child was placed with another child to build the block design, to work the puzzle, or to tell the story in the picture book. The trained child had the advantage of the untrained child, and proceeded to use his advantage, usually by assuming the role of teacher. After quite a bit of such experience, the trained child was

given an after-test identical with the fore-test, and his ascendance score was much higher than before, in most children. Control tests showed that the gain was not the result of the few weeks' increase in age (*11*, *19*).

In a similar experiment, children who showed little self-confidence in solving a problem were brought to a higher level of independent work by starting them with easy problems and promoting them to progressively difficult ones, always with encouragement but no actual assistance (*13*). Much the same experiment was tried some time ago on soldiers temporarily incapacitated by wounds so that at first they could not raise the arm. Their progress was hastened by use of a little instrument which showed exactly how high the arm was being raised. At first their achievement was slight, but the instrument made it visible and gave them a mark to reach and surpass the next day. Many experiments in the psychological laboratory have shown that visible achievement promotes self-confidence and is an incentive to further efforts.

Treatment of personality difficulties. Which is worse, to lack self-confidence or to have no confidence in anybody else? The worst of all is to have no confidence in either self or others, and such is the state of some badly disturbed individuals. The first step toward a "cure" is, often at least, to get the subject to have confidence in some competent adviser. The mental hygienist, when working with a maladjusted child, tries first to win confidence by seeing the difficulty from the child's own point of view, and then to secure the child's co-operation in some hopeful plan for improvement. The child, as well as the adviser, must be hopeful. Often the co-operation of the parents and a more confident attitude on their part toward the child are essential for successful treatment.

When the child's difficulty brings him into serious conflict with society, as in cases of stealing or incorrigibility, a change of home environment may be necessary. Antagonisms may have grown up between the child and other members of the family which cannot be overcome, and the child would slip

back into his old role if replaced in his old surroundings. A foster home is found for him after careful study of that home as well as of the child to make sure that the two will fit together. Follow-up of several hundred boys and girls placed out in this way revealed improvement in the great majority of cases (about 90 percent), except where the child's personality showed from the beginning distinctly abnormal trends. Stealing, lying and running away ceased, though not all at once, and timidity, irritability and distrust disappeared in a favorable home atmosphere. Precocious sex interest was allayed (*7*). Yet the children, after all, remained the same children. The overactive one remained overactive, though less disturbingly so, and the easygoing one retained that characteristic through all the change of behavior. In short, the biological, temperamental factors in the child's constitution continued to operate in the changed environment.

The individuals who are most dominating and aggressive in their overt behavior are not always the most self-confident at heart; they may be "compensating" for an inner sense of distrust and insecurity. They may be drawing too sharp a line between the self and the environment and so failing to participate wholeheartedly in group activities (*8*).

We shall return to problems of this general sort in the final chapter of the book.

INTERPLAY OF INTERNAL AND EXTERNAL FACTORS IN THE PERSONALITY

We have the endocrines and other biological factors in personality, and we have the environmental factors such as the group code, the family situation and the role of the individual in the group. Shall we wave aside the biological factors in favor of the social, or the reverse? What we must do is to recognize the importance of both kinds of factors, and to insist that personality is not a sum of these factors, but rather a product of their interaction. The individual is not molded like putty; he is aroused to activity by the environ-

ment and is developed by his own activity. At any moment his behavior depends on stimuli received from the environment and on his own "structure, state and activity in progress" (p. 26). That is, it depends on both internal and external factors.

The state of the individual depends largely on internal chemical factors, both temporary and permanent. A tired child behaves differently from the same child when well rested, being in a different chemical state. An individual suffering from thyroid deficiency behaves differently from the same individual when supplied with the thyroid hormone. An individual exposed for a considerable time to dearth of oxygen shows different personality traits from the same individual under normal atmospheric conditions. It is possible, though questionable, that the neurotic individual is below par in some chemical function, and that his self-confidence would be raised by normalizing his chemical state. Even so, the neurosis would not be simply a subnormal chemical state of the organism. It would be the way the individual responds to the environment when in that state, and if the state were permanent, continued activity while in that state would build up a false conception of the environment and an inadequate habit of response. We get a glimpse here of the intricate interaction of biological and social factors.

Two individuals playing practically the same role will play it differently because of their different internal constitutions. They may accomplish almost the same results, but do so in different ways according to their personal characteristics. Two leaders, for example, may both be effective and yet very different in their ways of leading. One may be forceful and the other gentle. Two similar individuals placed in very different roles will develop differently, because of the different activities demanded, and two unlike individuals placed in similar roles will develop differently because their own tendencies cause them to act differently. As this statement holds good even of young children, we may conclude that the internal and external factors interact from the beginning and probably to the end.

There is another point to consider. The individual passes back and forth from group to group, as between the gang and the home circle, or between the classroom and the football team, playing very different roles in different groups. If personality depended wholly on the role, multiple roles would mean multiple personality. Yet most of us who play two or more roles are not disintegrated. The typical case of multiple personality arises from the *refusal* of the subject to play the multiple roles that normally fall to the same individual. He tries to confine himself to the role of the serious and self-effacing person, without ever being normally aggressive or normally playful; and the roles which he refuses to play get played in special states into which he lapses against his will. By contrast the normal individual passes freely from one role to another and maintains his own unity and continuity throughout. This unity and continuity are certainly not provided by the environment but depend on the fact that the organism is itself a unit.

The continuity of personality illustrated by a case history. That the individual preserves a good measure of sameness as he grows up and comes into different environments is well brought out in the numerous case histories that have been published of neurotic and delinquent persons, "problem children" and the like. One would expect to find the same continuity in the biographies of the great, but these biographies are apt to be rather meager on the formative years. Much of psychological interest can be found in the life of the American humorist, Samuel Langhorne Clemens, better known as Mark Twain (*15*, *20*).

Mark Twain grew up in the semifrontier town of Hannibal, Missouri, on the Mississippi River. His father, a lawyer of high character and aspirations, was a poor money-getter, and the family was always close to poverty. His mother came of a family of optimistic people, full of projects for getting ahead, and was herself a woman of great vitality, courageous and outspoken, with a peculiar, interesting drawl in her speech and the art of saying a humorous thing "with the perfect air of not knowing it to be humorous." Mark Twain resembled his mother

in all these respects. She once replied to a neighbor who asked if she put any credence in the boy's astonishing tales of his adventures, "Oh yes, I know his average. I discount him 90 percent. The rest is pure gold." Sam, or Mark, was the sixth in order of seven children. He was cared for largely by negro slaves, was very fond of the stories they told, and retained a strong affection for the negro. Sympathy for the "under dog" was always one of his strong characteristics. He was the leader of a gang of boys who roamed the woods, swam in the River and explored it in "borrowed" boats. He was full of adventurous projects and practical jokes, and it was said of him that he always had a ready audience for whatever he had to say in his drawling way. One of his gang was the original of "Huckleberry Finn," the neglected son of the town drunkard, whose company was forbidden to the children of respectable families. Mark did not like school and when he was eleven, his father dying, his mother permitted him to go to work in a local printing office, where he soon learned to be an expert typesetter. Leaving home at the age of seventeen, he plied his trade in several large cities, and then suddenly, during a steamboat trip, determined to become a River pilot—the great ambition of his boyhood. He "learned the River" and piloted large steamboats between St. Louis and New Orleans for several years, until the outbreak of the Civil War put a stop to the river traffic. Soon afterwards, we find him in Nevada, then in the height of the silver boom. He dabbled in mining, optimistically, for a few months, but soon became a reporter on the leading newspaper of the region. (He had written a few sketches from time to time during his youth and early manhood.) A few years later he began to travel as a newspaper correspondent, and he ventured with much trepidation to try his hand as a lecturer. He had already, on one or two occasions, met with much success as an after-dinner speaker; and when he stood before his audience and just talked to them in his characteristic way, he carried all before him. He embodied some of his travel letters in his first book, *Innocents Abroad.* The success of this book led him to settle down, more or less, to the life of an author and man of means. He had found a wife after his own heart and was much devoted to his children. His wife became his censor and kept his writing within the bounds of respectability, from which he was prone to stray. Besides the creditable array of books and sketches which

he published, there were many which were censored and left unfinished. He was always willing to take a chance on what seemed like a promising invention, and sank a fortune in a type-setting machine. He became partner in a publishing house which after rather a brilliant career went bankrupt, and then, at the age of nearly sixty, set about paying off his indebtedness by going back to the lecture platform. He suffered many disappointments and sorrows from time to time and felt them deeply but always came back to high spirits.

There is an undercurrent of serious purpose in Mark Twain's writing—to strip off cant and prejudice and see things as they really are. He was extremely critical of much that was current in religion and public life, and used to rant about the "damned human race" which was to his way of thinking inferior to the animals except in the one point of intelligence. But his readers and hearers always suspected a joke, and would burst into laughter at his most serious statements. He had made his role and was held to it. Apparently he found his role even as a boy in his gang. Certainly his behavior shows continuity in spite of the varied environments in which he lived and the varied occupations in which he engaged. One should mention also certain personality traits which had much to do with his career and which were certainly biological or constitutional: his resilience and high spirits, his great endurance (he would play billiards all night without feeling tired) and his fulness of projects and disposition to take a chance.

Mark Twain's marked ability and striking personality reveal quite clearly the interaction of biological and social factors. The direction in which he developed was obviously determined by the social role that he filled, but his role was not handed out to him by society, for he showed unusual initiative in making a role for himself. He made his role by finding what an individual of his biological constitution could do that would have social value and acceptance.

Such a life history brings us squarely in front of a problem around which we have been skirting for a long time—the problem of the influence of heredity on personality, on intelligence, and on behavior generally. We have been willing to recognize the importance of the "biological factor," but we

have not assumed by any means that this factor is identical with heredity.

Summary of the chapter. The main topic has been the interplay of biological and social factors in the development of personality. The biological factors are best represented by the endocrine glands, the thyroid, the gonads, the pituitary and others; their contribution to the individual's personality stands squarely on the evidence. The evidence for social factors is somewhat more elusive but not open to serious doubt. The situation of the child in the home and in the play group was stressed for its contribution to the individual's code, role and "style of life." That some personality traits can be improved by suitable training, at least in childhood, was shown by experiments. Some clinical approaches to the difficult problem of improving maladjusted persons were described.

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Chapter VII

Heredity and Environment—Development

UP TO this point in our studies, individual differences in ability and personality have been described without much attention to ultimate causes. Where can we hope to find the causes except in heredity and environment? Under the head of heredity are included all the factors that were present in the organism at the beginning of its individual existence, and under the head of environment are included all the forces that have acted on it from without. It would seem that the possibilities are thus exhausted. Behavior depends on structure, structure on previous development, and development on the interplay of hereditary and environmental factors. So intricate is this interplay, however, that the effects of heredity and environment can scarcely be separated. Indeed, once the organism is partially developed, its existing structure embodies the results of the previous interplay of forces. It is the organism, together with its present environment, that is the direct cause of the next step in development. Any step in development is a kind of response, and like other responses it depends on present stimuli and on the organism. The individual as an organic whole makes the developmental responses. In a very real sense the individual develops himself.

The study of heredity and environment must at the same time be a study of the individual's development. Both topics are therefore included in this chapter, and our question regarding the causes of individual differences will not be fully met till near the end of the chapter.

The question whether individual differences are due more

to heredity or environment opens up a large scientific problem with important practical bearings. If superiority and inferiority are due mostly to heredity, the best hope for the future of mankind lies in improving the breed, and any tendency to racial deterioration calls for the most vigorous resistance. If the contrary view is nearer the truth and the main source of individual differences lies in the environment, all humanitarian efforts may well be directed toward better environmental conditions, physical and social. Shall the gardener pin his hope on careful cultivation of the soil or on selection of the best seed?

The practical gardener knows that both are necessary. A superior crop cannot be grown from inferior seed, no matter how rich the soil, nor from the best of seed in poor soil. Animal development, too, depends on both heredity and environment, as is well known to the breeder of fine horses, dogs or cattle, and it seems almost certain that the same holds good of mankind and that it would be sheer folly to neglect either heredity or environment in laying plans for human betterment.

EARLY DEVELOPMENT

About nine months before birth the human individual begins his career as a single microscopic cell, the fertilized ovum, which is an ovum from the mother's gonads combined with a spermatozoon from the father. With the fusion of these two cells into a single cell, the individual comes into existence. In the favorable environment supplied by the mother's body this one-celled individual immediately starts to grow, dividing into two cells, into four, into eight and eventually into millions and billions. These daughter cells take on different characteristics and form the various tissues and organs of the body, some becoming skin cells, some muscle cells, some nerve cells, and so on. In spite of all this multiplication and differentiation, the cells continue to interact with each other and the organism remains an integral whole, a perfect example of unity in multiplicity.

The carriers of heredity—chromosomes and genes. If we ask where the individual's heredity resides, we see that it must be wholly contained at first in the fertilized ovum and that

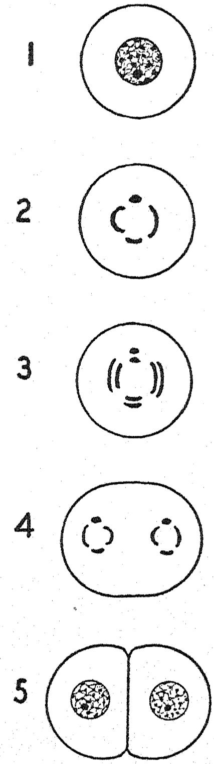

FIG. 24.—Cell division. First the nucleus breaks up into its parts or chromosomes, here 4 in number. Each chromosome then splits into 2 slender rods, one of which moves to the right and the other to the left. The two chromosome groups thus formed are identical with the original group except for being smaller. Next the whole cell divides, each daughter cell including one of the chromosome groups. This process of cell division occurs when the fertilized ovum divides and also when any one of the daughter cells divides. Instead of the 4 chromosomes shown in this simplified diagram, there are 48 in every human cell.

no more heredity can get in after the moment of fertilization. Like all other cells, the fertilized ovum consists of a semi-fluid mass called cytoplasm, and within that a small nucleus of somewhat denser material; and it appears that the hereditary factors are all carried by the nucleus. The nucleus takes

the lead in the process of development. Cell division starts with the nucleus. The chromosomes, rod-shaped bodies which make up the nucleus, deploy in regular order and split, each forming two daughter chromosomes, one for each of the daughter cells that soon result from the division of the whole cell. Thus each of the daughter cells possesses chromosomes identical with those of the fertilized ovum, and as the process is repeated in every subsequent cell division, the result is that the chromosomes of the fertilized ovum are reproduced in every cell of the body. Since the chromosomes are the carriers of heredity, we conclude that the individual's heredity, instead of being localized in any one organ, is fully present in every cell of the body, and plays a part in every activity from the beginning and throughout life.

The chromosomes are not the elementary carriers of heredity; each can be shown to contain numerous factors or "genes." The genes are known in the first instance by their effects on the development of the individual and on his adult characteristics, but in some cases it is possible to count the genes present in a chromosome and to show how they are arranged in the chromosome. Each chromosome in a given species is a definite combination of genes which usually stick together in heredity. The genes are the ultimate carriers of heredity. They react to stimuli from the environment and from inside the partially developed organism and so affect the individual's structure and behavior (*25, 35*).

The source of heredity. Tracing back the chromosomes of the fertilized ovum we find half of them present in the unfertilized ovum and the other half in the spermatozoon. Half of them are supplied by the father and half by the mother. That is, half of the child's heredity comes from the father and half from the mother. The mother's additional contribution to the child's welfare during pregnancy belongs wholly on the side of environment and does not affect his heredity.

But the child does not receive *all* his mother's chromosomes nor all his father's. If he did he would have a double number; he would be a freak. Prior to fertilization the ovum

extrudes half of its chromosomes, and the spermatozoon does the same. Thus the child receives only half of his mother's stock of chromosomes and half of his father's stock. In this process there is a large element of chance as to exactly which chromosomes come from the mother and which from the father. Millions of combinations are possible, and two children of the same parents very seldom get the same combination, very seldom have the same heredity, though they are more alike in their genes than unrelated children. Each individual's heredity is practically unique. (For an exception see p. 231.)

What does the child inherit, in the strict biological sense, from his parents? He inherits chromosomes, genes. He does not get the sum of his two parents' genes; he gets only half of those that operated in either parent. Because he is genetically a new combination, his visible traits of structure and behavior may differ greatly from those of either parent. Leave environmental effects out of account; just by heredity children on the whole are bound to differ considerably from their parents.

The words "heredity" and "inheritance" are somewhat misleading since they lead our minds back to the parents, whereas we ought to be thinking of the child's own unique combination of genes. *Heredity for any individual is his own native constitution.*

Environmental factors in prenatal development. Up to the time of birth the growing organism is so completely sheltered from the heat and cold, the jars and stresses, of the outside world that development—we are likely to imagine—must depend wholly on heredity and not at all on environment. Then we remember that the unborn child's immediate environment is not the "outside world" but the mother's body and particularly the uterus or womb. On this immediate environment the organism depends for such essentials as food and warmth, and without them no development would occur. From the very beginning development depends as truly on environment as on heredity.

Relative importance of heredity and environment: (1) in the development of a single individual. It has sometimes been argued that heredity, however potent in the first stage of development, must become relatively ineffectual as development proceeds and the effects of environment accumulate in the organism. If heredity is completely present in that microscopic cell, the fertilized ovum, how can it play any considerable part after the organism, by taking in material from the environment, has grown into a twenty-pound baby? The answer is that the absorbed material does not dilute the original living substance, for in being absorbed it is transformed by the organism and enters fully into the life of the cells. All the milk consumed by the baby fails to make him more and more milky, for he changes it chemically into human muscle, bone and brain. The hereditary factor carried by the ever-multiplying chromosomes is present in every cell of the body and is just as influential in the later stages of development as at the very beginning.

A maple and an elm stand side by side. In the spring when they put out their leaves, look!—the leaves of the two trees are different. Which factor makes them different, heredity or environment? For all the years of age and all the tons of bulk that separate them from their original seeds, the hereditary difference remains in every bit of new growth. Without the hereditary factor, indeed, there would be no leaves on either tree, there would be no life. And without the environmental factors of warmth and moisture there would be no leaves. Heredity and environment work together in every manifestation of life.

The relation of heredity and environment is not like addition but more like multiplication. The individual does not = heredity + environment, but does = heredity × environment. The weight of an elephant is not the sum of two parts, one part due to his heredity as a large animal, the other part due to the amount of food available. If it were, a mouse growing up in the same jungle would be equal to the elephant in the environmental part and differ only in the part due to

heredity. Development is a product rather than a sum of the two factors.

Let heredity be represented by the base of a rectangle, and environment by its altitude. Then the individual's development is represented by the area of the rectangle, the product of base and altitude. We cannot say that the area depends more on the base or more on the altitude; for if either should

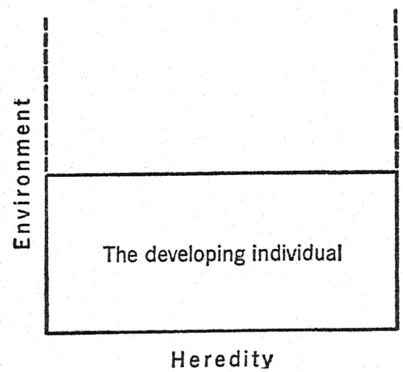

FIG. 25.—The individual a product of heredity and environment. Increase the environmental stimulation (height of the rectangle) and you increase the area, but the hereditary factor (width) remains as important as ever.

drop out there would be no area left. In the same way it is absurd to think of either heredity or environment as being more important than the other in the individual's development.

Relative importance of heredity and environment: (2) in causing differences between individuals. So long as we are following the development of any single individual there is no point in asking whether heredity or environment is more important, since both are absolutely essential. Usually, however, when we raise this question we are comparing one individual with another and asking what makes them different. Why is one taller, or brighter, or more self-centered than the other? The *cause of the difference* might lie in heredity alone, or in environment alone, or in both together. Two individuals of the same heredity might differ because of un-

like environments, and two individuals of differing heredity would probably differ in spite of identical environments. So we should logically expect; change either factor and you change the product. But logic alone does not tell us *how much* difference to expect from heredity alone or from environment alone. All the big, important differences among men might be due to heredity, or to environment. Such a question can only be answered by detailed investigation.

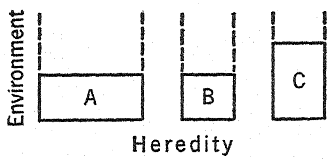

FIG. 26.—Individuals may differ because of differing heredity or because of differing environment. Thus A and B receive the same amount of environmental stimulation, but differ (in area) because of their different heredity; whereas B and C, though having the same heredity, differ because they receive different amounts of environmental stimulation. The *size of the difference* between two individuals always depends on both factors. Take A and B and double the environmental factor (height): you double the amount of their difference (*8*). Let A be an elephant and B a mouse. If food is scarce their weights differ by a certain number of pounds, but if food becomes plentiful the elephant will gain more pounds than the mouse and the absolute (not relative) difference in weight will be larger than before.

For the same reason we should expect a naturally bright child and a dull one to differ somewhat in knowledge even if brought up in a very meager environment, but if the environment became richer and more stimulating the bright child would pick up more new knowledge than the dull one, so that their stocks of knowledge would differ more than before. In general, improving the environment for all alike should increase the amount of individual differences (p. 237).

Fundamental experiments on heredity and environment. The logic of investigation is clear. To discover the effect of differences in heredity, make heredity your "independent variable," holding environment constant (p. 9). That is, take individuals of different heredity and expose them to identical environments; any difference in the result must be laid to heredity. Similarly, to appraise the influence of environment, take individuals of identical heredity and expose them to different environments. These two types of experi-

ments have been tried many times and in many ways on plants and animals.

Hybrids prove the importance of heredity in individual differences. If a male of one species is mated with a female of a different (though necessarily similar) species, the offspring is known as a hybrid. With the male a donkey and the female a horse (mare) the offspring has the same prenatal environment as a normal horse and should therefore be born a horse, if only environment counts. But the offspring turns out to be a mule, differing considerably from a horse at birth and becoming more and more characteristically a mule as he grows up. From this instructive and often repeated experiment we learn:

1. that the difference between a horse and a mule is due to heredity, i.e., to the fact that half of the mule's chromosomes are donkey chromosomes;

2. that creatures of different heredity are not made alike by exposure to the same environment;

3. that hereditary differences come out more and more as development advances.

In a less striking way the same facts can be observed in human children whose parents have differing physiques, for the child does not "take after" his mother more than after his father, though his prenatal environment is exclusively maternal. This environment does not "mold" him in any such way as to eliminate his hereditary characteristics.

Hybridizing or cross-breeding experiments in great variety have been tried by geneticists, and the amazing body of knowledge achieved from the day of Gregor Mendel, 1866, down to the present day should be examined by anyone who is skeptical regarding the importance of heredity (25, 35).

Monsters prove the importance of environment in the causation of individual differences. If development is not a "molding" process, is it merely an "unfolding" of characteristics that are fully determined in advance by heredity? The negative is proved by a second type of experiment, in which an individual of normal heredity is made to develop under abnormal environmental conditions. There are obvious dif-

ficulties in the way of doing much with unborn mammals, but birds' eggs can be treated in various ways during incubation, and fish or frog eggs while developing in the water can be heated, chilled or exposed to the action of chemicals, electricity, X-rays, etc. The outcome is often a "monster," an individual differing grossly from the norm of the species. For example, fish embryos, just at the eye-forming stage, were placed in the icebox for a few hours, with the result that the eyes were imperfectly formed, and some individuals developed only a single eye. The difference between the one-eyed fish developed in the cold and the two-eyed fish developed under normal conditions was clearly due to the difference in environment (*41*).

These biological experiments, showing very marked individual differences due in one case to heredity and in the other to environment, are probably sufficient to disabuse our minds of any prejudice against either factor. We are prepared to believe that important psychological differences can result from either factor. Before coming to grips with that question we need to examine somewhat further the *process of development* which is well worthy of study on its own account as well as for the light it throws on individual differences.

MATURATION *VS.* GROWTH THROUGH USE

We have discarded the all-too-simple views (1) that the development of an individual is a spontaneous unfolding of his inherited characteristics, and (2) that it is a molding process in which environment does the work and the individual remains passive. Development is an active response of the individual to stimulation. A new problem now presents itself, suggested by the questions, whether the muscle is developed by being exercised or by a natural growth process, and similarly whether the brain develops as a result of brain activity or by a natural growth process. The word "natural" is really out of place here, since growth resulting from activity would be a perfectly natural process. What is meant by "natural

growth" or *maturation* is a kind of development that does *not* depend on the use, function or characteristic activity of an organ. Growth of the muscles resulting from other causes than muscular exercise, growth of the brain resulting from other causes than the use of the brain in learning, thinking, etc., would be examples of maturation.

Most of us would accept without question the genuineness of both sorts of development. We know, or think we know, that exercising a muscle increases its size and strength. We certainly know that practicing an act results in greater skill and power. These are instances of development through use. We also know, or think we know, that the child grows in size, that his teeth come and his bones harden, that many other changes take place in his various organs and that, in short, he becomes mature, not so much by exercise and practice as by the natural process of growing up. We should be inclined to accept the following two statements which however are here put forward as hypotheses to be tested.

1. The activity or use of an organ results in the further development of that organ, unless it is already well developed, and maintains it in good functional condition if it is already well developed; whereas prolonged inactivity results in a loss of good condition and finally in "atrophy through disuse."

2. There is also a maturation process by which the fundamental structure of an organ is laid down prior to use, and this process does not necessarily cease when the organ begins to function. The causes of this growth-without-exercise remain to be considered.

Though these two statements appear reasonable, each of them has been much doubted. Some psychologists are skeptical regarding maturation and others regarding growth through use, while still others insist that the two processes are really the same.

Evidence for maturation. It seems undeniable that any organ must develop to a certain point before being capable of functional activity. The heart could not start pumping the blood through the arteries until it had become a workable

pump. The lungs afford a convincing example. No air can possibly enter the lungs before birth to distend and exercise them, and yet at birth they are well enough developed to play their part in breathing. Their further development after birth may be the result of using them, but their prenatal development belongs squarely under the head of maturation.

Or take the muscles. Each muscle first makes its appearance long before birth as a little "bud" having no contractile power. The cells of this rudiment multiply and take on the structure of muscle fibers. At the same time a nerve is growing out from the nerve centers to the muscle. When this process has gone far enough the muscle begins to receive stimuli from the nerve centers by way of the nerve, and to respond by contracting. Until the muscle has developed its special structure and until its connection with the nerve centers is established, it remains inactive and therefore this early development is due to some cause other than its own activity.

The cause of maturation. The most striking thing about maturation is not the increase in the size of the embryo—though that is striking enough—but the *differentiation* of cells and the formation of many diverse organs. All the cells of the body are descendants of the fertilized ovum, and yet some become muscle cells, some gland cells, some nerve cells. What causes them to differ? They all have the same chromosomes, the same heredity. Reasoning as we did in explaining the differences between individuals, we say that cells having the same heredity can differ only because of differing environments. But the external environment is essentially the same for all parts of the young embryo, shielded as it is. The immediate surroundings of any cell in an organism, however, consist of other cells within that organism, and when some differentiation has already occurred, different cells of the embryo have different surroundings and receive different stimulation from the surrounding cells. (The reader will query how differentiation gets its first start. Apparently it starts in the fertilized ovum, perhaps in the process of fer-

tilization.) Receiving different stimulation, different cells in the same embryo respond by developing differently.

The differentiation of cells and organs, accordingly, must be due to their different surroundings within the developing

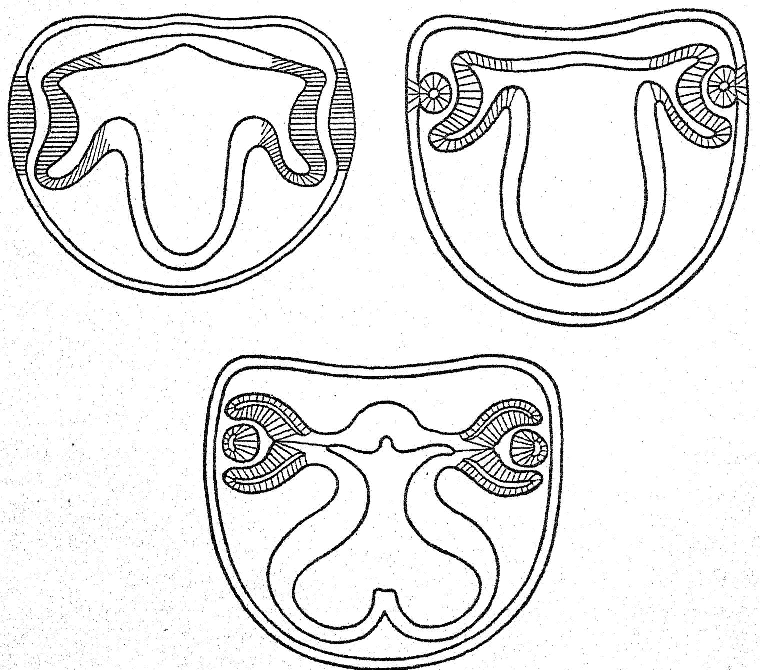

FIG. 27.—Stages in the development of the eyes. In the first stage the eye-buds, growing out from the embryo brain, approach the skin and stimulate it to thicken. In the second stage each eye-bud takes the shape of a cup while the thickened parts of the skin are rounding out into separate bodies. In the third stage these round bodies are enclosed in the cups, where they develop into the lenses of the eyes. The cupped eye-buds develop into the retinas.

organism. Each embryonic cell is influenced by its immediate surroundings. This fact is well seen in the early development of the eye. The first rudiment of each eye is an outgrowth from the rudimentary brain toward the rudimentary skin of the rudimentary face. All the parts are rudimentary at this stage and all the cells are much more plastic than they are later. The *eye-bud* growing out from the brain exerts a stimulating influence on the skin cells that it approaches,

and this part of the skin thickens and forms the lens of the eye, while the eye-bud forms the retina and iris. (For these parts see Fig. 90, p. 474.) Other adjacent tissues are stimulated and develop other parts of the eye. As they are formed, these various parts come together and make up the eyeball.

Descriptive embryology traces this course of events but can only guess at the causes at work. The experimental embryologist goes after the causes by aid of an experiment which deserves a place beside the hybrid and monster experiments mentioned earlier in the chapter. This is the *graft experiment*, or transplantation experiment. A fresh piece cut from one part of a developing organism is transplanted to another part of the same organism or even grafted upon another more or less similar organism. Varied experiments of this general type are throwing much light on the nature of differentiation and maturation. We will notice only the results of grafting an eye-bud into some other part of the same embryo. If transplanted so as to lie under the skin of the abdomen, at just the right stage of development, the eye-bud chemically stimulates the skin and adjoining tissues and induces the development of a fairly complete eye in that remote region. The eye-bud is evidently a center of influence and dominates the surrounding cells (*40*). Similar events happen throughout the developing organism. The head gets its start early, takes the lead, and dominates the development of the rest of the organism, even before the brain is well enough developed to exert any control through the nerves. Some of the hormones begin early to have an effect on development.

In this process of maturation, the external environment plays an essential part by supplying food and oxygen, warmth and other general conditions of life. Heredity is of course always in action, different genes responding in different parts and at different times according to the stimulation received. But the decisive factor in differentiating the various organs is the *interaction of parts within the organism.* The organism is a system in itself, though of course only partially separated from the external environment. Here, very concretely, we

see the meaning of our opening statement that "in a very real sense the individual develops himself."

Growth through use or functional activity. The growth of a muscle from repeated exercise is a matter of "common knowledge," but we learn in psychology to be suspicious of common knowledge and to demand definite facts in support of our conclusions. Exercise undoubtedly *strengthens* a muscle that has become flabby from want of exercise, but the gain in strength is much greater than can be accounted for by the relatively slight increase in the size (thickness) of the muscle. Other results of exercise besides muscular growth contribute to increase the strength: better circulation and oxygen supply, increased storage of fuel reserves in the muscle, stronger stimulation from the brain. The shrinking of a muscle when immobilized for weeks in a splint, and its gradual recovery after the splint is removed, look like good evidence for atrophy through disuse and for growth through use. But a well-controlled experiment would be much more conclusive.

Muscle growth from exercise demonstrated. There is one experiment, made in 1897 and apparently so well done that the physiologists have not thought repetition necessary (*26*). A large mature dog was first kept inactive for a month. Then the slender sartorius muscle was removed from one thigh of the animal and carefully preserved for microscopic examination. After recovery from the operation the dog was trained in running a treadmill. He ran but little at first but after 20 days of training he was making the equivalent of 40-50 miles a day and kept this up for 40 days, covering the equivalent of 2,000 miles in all. Now the sartorius muscle was removed from the other thigh, and the two muscles, one unexercised and the other exercised, were compared. The exercised muscle was 50 percent larger in cross section than the other. Actual growth of muscle substance had resulted from the exercise.

Microscopic examination of the cross sections showed about 30,000 muscle fibers in each case. Exercise had not increased the *number* of fibers; there had been no cell multi-

plication. But exercise had increased the thickness of the fibers, especially of the many very slender fibers present in the little-exercised muscle. These slender fibers provided a reserve available for development through exercise. A second, smaller dog was put through the same experiment with essentially the same results.

Evidence that the brain also is capable of some structural development through use will be presented in the next chapter (p. 287).

The two developmental processes compared. Admitting that both maturation and growth through use are genuine, we ask next whether they are essentially one and the same process, as some have thought. They are alike in being responses to stimulation, but the *stimulation differs* in the two cases. Maturation depends only in a very general way on stimulation from the external environment. Directly and specifically it depends on the interaction of parts within the young organism, one part stimulating another to develop. But the development that results from functional activity depends very specifically on stimuli received from the external environment, because it is in response to such stimuli that functional activity occurs. The dog in the experiment exercised and strengthened his muscles in response to the environmental conditions imposed by the experimenter. Maturation equips a creature with organs suited to its general environment—with fins, wings, or hands and with the muscles, sense organs and nerve centers required to operate these organs—and leaves the details to be worked out in the individual's active dealing with his own particular environment. All learning belongs under the head of development through activity.

Maturation and growth through use are also *different responses*, different kinds of growth. In the experiment just cited the dog's muscle fibers increased in size and perhaps in efficiency but they did not increase in number nor change into any new kind of cells. In a typical case of maturation such as the early development of the eye the cells multiply and differentiate. They are embryonic and plastic at the

start but in the process they assume definite structure and are combined into definite organs. They lose much of their plasticity as they take on the structure that fits them for certain functions. The changes resulting from use are much less radical though they are important in adjusting the organism to a particular environment.

Does maturation cease when use begins? It is reasonable to believe the two developmental processes can go on together. Interaction within the organism continues even after active dealing with the environment is in full swing. To be sure, the developed organs lie relatively far apart and are rather insulated from each other, but the hormones carried by the blood stream are known to have a powerful influence on development, even up to maturity (pp. 172, 176-178). What we should especially like to know is whether the increased strength and skill that appear as the individual grows up are wholly due to activity or partly to continued maturation. Is such improvement wholly the result of learning or partly the effect of maturing? An experiment on young chicks throws some light on this question.

If kernels of grain are strewn on the ground before a chick one day out of the shell, it pecks at them, seizes them in its bill and swallows them; but, its aim being poor, it actually gets only 20 percent of those pecked at; the next day it may get 50 percent, in another day or two 75 percent, and in about ten days it reaches a score of 85-90 percent. Does this improvement picture the course of maturation or the development resulting from practice? To investigate this question, chicks were hatched in the dark, kept in a dark room, hand fed and so prevented from pecking for 2-5 days, and then brought into the light and given a chance to peck at grain. Their score on the first day in the light was no better than that of the one-day-old chick, but they improved more rapidly with practice. The experiment proves two things: (1) continued maturation during the 2-5 days in the dark, shown by the more rapid improvement after practice was begun; and (2) the need for practice to bring the pecking act to high efficiency, shown by the low initial score even

after the extra maturation. Here, as often, maturation provides a mechanism that will work, and the use of the mechanism makes it stronger and more accurate (*4, 31*). Maturation does not make learning superfluous; it simply prepares the way for activity and learning. Each forward step in maturation equips the individual for commencing new activities and so makes new learning possible.

BEHAVIORAL DEVELOPMENT

We turn now from the background topic of structural development to the more strictly psychological questions connected with the development of behavior. We wish to estimate the relative importance of maturation and use or exercise in the transformation of the infant's behavior into that of an adult. We ask whether the child increases in intelligence, and decreases in playfulness, simply by growing up, or simply by learning, or by both processes combined. In seeking an answer we will appeal to the students of child development who are following one of the most promising leads in psychology. Developmental psychology is a much larger subject than we can attempt to cover adequately (*10, 27*).

Prenatal activity. The unborn child is far from being an inert mass, as is well known to the mother who feels its body move from the middle of pregnancy in increasing amount. More exact studies of prenatal behavior are possible in cases of premature birth. The first muscular activity is the heart beat which starts at about the third week of embryonic life. The skeletal muscles begin to be active in the third month, bending the trunk, changing the posture and moving the arms and legs. As development proceeds the movements become stronger and more varied.

The senses develop early and are capable of function some time before birth, but the eye and the senses of taste and smell can scarcely receive any effective stimuli in the sheltered uterine environment. Muffled sounds doubtless reach the ear and motor response to loud external sounds has been

observed before birth. The sense of touch and the muscle sense are stimulated by the child's own movements. The muscle sense in particular gets a great deal of use; and the lower nerve centers are in use whenever the muscles and muscle sense are active. Probably, therefore, this whole system—muscles, muscle sense and nerve centers—is developed in part by prenatal exercise. This system is responsible for the fundamental postures and movements of trunk and limbs. Certain acts, however, can apparently receive no exercise at all before birth. When the newborn baby sneezes, one thinks, "How clever! How did he learn that trick?" He has had no chance to learn it, since it cannot be performed without inspiring and expiring some air. The same can be said of coughing and crying and of breathing itself. The neuromuscular mechanisms for these acts must have been prepared by maturation alone, up to the time of birth.

Combination and segregation as principles of behavioral development. Bound up with the problem of maturation and use is the question whether small local movements or large inclusive movements come first in development, and whether the large acts are formed by combining the small ones, or the small acts by dividing the large ones and segregating the smaller act out of the larger. In later life both kinds of development occur. Movements of the two hands are combined in playing the piano, but the beginner must also learn to move the fingers separately instead of all together as is more natural. How is it in prenatal development?

In the young salamander developing in the water the first movements to appear are head and trunk movements which bend the whole body away from a stimulus or propel the little animal through the water. As the limbs take shape they participate in this swimming movement before being able to move separately. Here the big movement comes first and the smaller one seems to emerge from the big one by a process of segregation. On this basis it has been suggested that segregation and not combination is the law of behavioral development (*9*).

Prenatal behavior has been examined in several other ani-

mals and some human data have been obtained by observation of the prematurely born. This line of investigation is still in progress and final conclusions cannot yet be drawn. Large movements involving head, trunk and limbs appear early, but small movements of fingers, lips, tongue or eyelids are just about as early (*6, 27*). Carefully examined the small movements are seen not to be exclusively local; there are always slight movements in other parts. Nor are the large movements ever total; there are always parts of the young creature's body which are quiet at the moment. Even these early movements are both selective and co-ordinated (*14*).

Activity of the newborn child. At birth the child possesses a varied assortment of movements, large and small. And it cannot be too strongly emphasized that each of these movements is an organized whole. Sneezing calls for deep inspiration followed by forcible expiration. Crying calls for gradual expiration with opening of the mouth and tension of the vocal cords. The two eyes move together like a team. Raising the arm or leg calls for teamwork from the muscles that bend the different joints. All these movements are graduated in force, and combined and recombined in all sorts of ways. The action system, as seen in the newborn child, is complex, flexible and highly organized at its own level.

The newborn child's behavior at certain moments, as when he is hungry and crying excitedly, gives the adult observer the impression of a disorganized mass. One trained observer reports:

> The infant maintains continuous body movement with such speed and excessiveness that the experimenter . . . cannot keep up with the infant. The body squirms, twists, rolls, and bends. The back arches, the hips sway, and the head rolls from side to side or is thrown back. The arms slash vigorously and the legs are kicked in exaggerated extensor thrusts or are flexed sharply at ankle, knee, and hip. Hands, feet, toes, and fingers are in continuous movement. Sucking and smacking sounds frequently occur, while loud crying is usually coincident with mass activity (*12*).[1]

[1] Quoted by permission of the author and of the Clark University Press.

The term "mass activity" is misleading if it is allowed to obscure the fact that each of these movements, whether kicking, arm slashing, back arching or body squirming, is a well-organized movement, taken by itself. A real mass of disorganized muscular activity would be something entirely different. It would be a general spasm or else a muscle twitching here and there with no definite movements of body or limbs. The observer calls it a "mass" because the sequence of acts is too rapid to follow, and because, to adult eyes, the whole performance is not getting anywhere. In quieter moments the infant executes these same movements separately and learns to select and combine them so as to accomplish results in the environment, thus organizing his behavior on a second and higher level. But he starts, at birth, with movements that are already well organized at the fundamental level.

Learning(?) to walk. There is some reason to question the usual assumption that the human child has to learn to walk. Certainly the parents do not *teach* him to walk, for very few people understand the act of walking well enough to teach it. The adult can encourage the child and protect him from bad falls, but if the child learns to walk he does so through his own efforts. Many animals walk as soon as they are born; maturation does the spadework for them, and the mere fact that the human child's postnatal development is so long-drawn-out need not mean that maturation is any less helpful in his case. But we need evidence rather than such reasonings.

During his first year after birth the child develops along two lines which come together about the end of the year in the act of walking. One line we may call *locomotion* and the other *balancing*. At the age of 6-7 months he tries to move himself along the floor and at 8 months probably succeeds in crawling. A little later he can raise his body on his hands and knees and at 9 months can creep. He next tends to make more use of his feet, getting one or both of them on the floor as he creeps, and sometimes walks on all fours for a short time before he passes over to erect walking. The

stages in this sequence are gone through in the same order by almost all children (*2*).

Balancing also shows a uniform sequence of stages, the head being first held upright, then the trunk as in sitting, and finally the whole body as in standing. The child holds his head up steadily at 4 months, sits up steadily at 7-8 months, stands and walks with support at about 10 months, and walks alone at 14 months. In walking he at first keeps his feet wide apart and his arms spread, but as his balance improves his feet follow a narrower path and his arms are free for other uses. Children differ considerably in the age at which any of these stages is reached, but the sequence is always the same with only minor variations (*3, 32*).

These *uniform sequences* in creeping and balancing suggest maturation rather than learning. If the development depended primarily on learning, the order of the stages should differ according to the child's environment and the stimulation received. If it depended on learning and exercise it should be speeded up by intensive training. Johnny and Jimmy were twins, very much alike though not "identicals." Johnny was trained, Jimmy was kept relatively inactive. Johnny's training began within the first month and afforded him unusual opportunity and stimulation for crawling, creeping and standing as well as climbing and swimming and later for roller skating. His remarkable achievements in these more specialized activities were a revelation of what a young child can learn to do. But he did not sit up or creep or walk any earlier than his untrained brother. His training did not hasten the development of the basic forms of locomotion and balancing. These apparently depend on maturation so far as concerns the time at which they become ready to function (*20, 21*).

It is reasonably certain that the child does not learn to walk in the full sense of the words. Without maturation of his legs and of his balancing mechanism he never could learn to walk. But nothing is more characteristic of the growing child than his eager use of all his powers. He gives them abundant exercise and so strengthens them and makes them

more skillful. Excess movement is eliminated and different acts are combined. If the child does not learn to walk, at least he learns to walk well, to walk easily, to carry things as he walks.

Voice and speech. From birth on there is some ability to use the vocal organs, as shown in crying; and crying improves with use. Grunts are made during the first few weeks and syllables like *goo* at about 2 months, followed a few weeks later by two-syllable units. Baby talk which is conversational to the extent that it is directed to another person, with give and take, starts at about 6 months, expressive inflections and intonations at about 9 months. The first word recognizably imitated from adult speech occurs at about 14 months on the average. During the second year the number of words used increases slowly and then rapidly, and phrases and short sentences make their appearance near the end of the year (*33*).

This sequence is almost invariable, in spite of large individual differences in the *rate* of progress. The inference is that maturation is essential. The child cannot utter syllables until his speech organs and nerve centers have matured to a certain point, and he cannot pick up words by imitation until his nerve centers have advanced some distance farther. The child must learn to speak, certainly, but he is not ready to learn until maturation has advanced to a certain stage.

Social development. A child of less than two years in a nursery school pays little attention to the other children and plays mostly by himself. Shortly he begins to watch the other children and to make rudimentary social contacts with them by touching, pulling and pushing. At about three years he likes to be doing the same thing that other children are doing, though without much give and take. Social play increases gradually and at five or six years we find the children engaged in dramatic play and co-operative construction projects. The sequence is regular enough to suggest a process of maturation, but it need not be specifically a social maturation, for it is closely bound up with the child's general intellectual development. And it is clear here, as in the

child's talking, that a tremendous amount of exercise and learning is superimposed on the growing-up process (*38*). Rudiments of sympathetic behavior appear quite early, but real help to a fellow-being in need is impossible till the child's general intellectual development has made some progress. He must comprehend the situation before he can act effectively. For reasons that are not at all clear some children are much more sympathetic than others of the same age. The same child may appear both very selfish and very helpful, probably because he is active and uninhibited (*28*).

Personality development. When we compare the mobile, playful but dependent child with the self-reliant, serious and slow-moving adult, we are ready to believe that both maturation and learning are needed to produce such a transformation. The adolescent is eager to *learn* the ways of the adult, to acquire the adult code of behavior and to find for himself a role in the adult world. He learns what he can and may do and what is expected of him as a grown-up member of society. The pronounced shift of interests that occurs early in adolescence, away from the aspirations and amusements of a child and toward those typical of an adult (p. 188), has sometimes been attributed to learning alone. But why does this shift of interests occur two years earlier in girls than in boys? Is it not tied up with the physical *maturation* of puberty which occurs two years earlier in girls than in boys? Just before puberty physical growth takes a spurt, as shown in Fig. 28, and soon the girl begins to menstruate and her figure becomes that of a woman, while in his turn the boy's voice changes and his beard starts to grow. These physical changes are due in large measure to the hormones of the gonads and pituitary and must be credited to maturation.

Outstanding personality changes in adolescence are the increased sex interest and spirit of independence. Sex interest is certainly not due to learning alone, since it depends on the hormones. The youth's independent spirit may depend largely on reaching adult size and strength. As a child one looks up, literally, to the adult; as a youth, one looks straight forward at him. As a child one may have rebelled in a

rather futile way against adult authority, but as an adolescent one feels large and strong enough to assert one's independence. One enters a new world because one is taller, stronger and more responsive to the other sex. However, the trans-

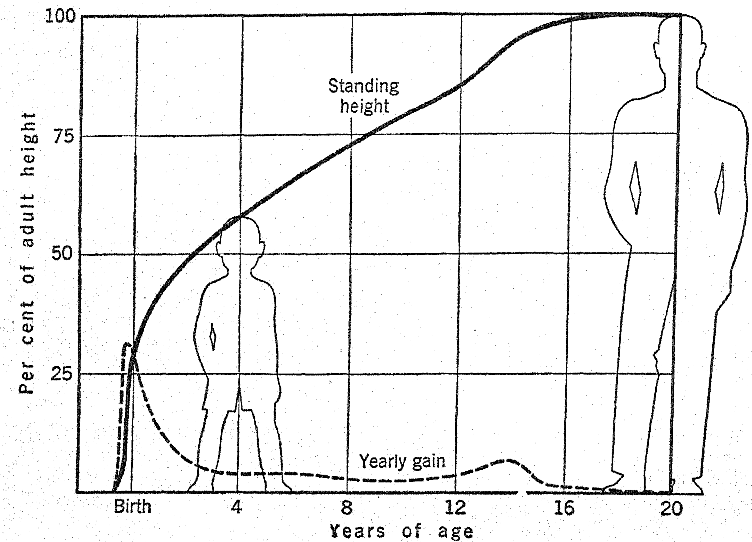

FIG. 28.—(Data from Shuttleworth, *32.*) The growth of stature from before birth to maturity. Just before puberty each individual shows a second spurt of growth. The first spurt, as shown in the dotted curve of yearly gain, is at its peak before birth. The second spurt occurs at a variable age, from 10 to 15 years in girls, from 12 to 17 in boys. Because the prepubertal spurt occurs at different ages, it will not appear in an average of all boys or girls. This curve was obtained by averaging only boys who showed the greatest gain in height at the same age. Repeated measurements of the same individuals are necessary in order to obtain an accurate picture of growth.

formation is not instantaneous by any means, and much learning and gradual adjustment attend and follow the maturation process.

Development of intellectual ability. Binet, we remember, based his tests on the fact that children become more intelligent, more capable mentally, as they advance in age up to adolescence. We recall also that the limit of this advance seems to lie in the teens, with some question whether early or late in that period (p. 120). It appears certain that the

curve of mental development flattens out during the teens into the adult level. Intelligence test scores increase only slowly after age 12 or 13, and perhaps not at all, on the average, after 16-18. There are several questions one would like to answer in regard to intellectual development. One would like to know whether there is any adolescent mental spurt, like the prepubertal spurt in physical development shown in the growth curve for height (Fig. 28). One would like to know whether the level reached at 18-20 remains steady throughout adult life. And one would like to know whether intellectual development is to be credited to maturation or to activity and learning.

The mental growth curve. Judging from the curve of physical growth, we should expect intellectual growth to become slower year by year from birth up to early adolescence, with more or less of a spurt at that time followed by a flattening out into the adult level. This would be the curve to be expected from maturation; so far as the development depended on learning, there would be no reason to expect an adolescent spurt.

An intellectual spurt in adolescence is possible but by no means proved. If a fact, it would be difficult to establish, because the spurt would certainly occur at different ages in different individuals, as it does in physical growth. The same individuals would need to be tested repeatedly throughout childhood and adolescence. When this is done, some individuals show what appears to be a spurt somewhere between 12 and 17 years of age, just before or just after their puberty, but other individuals show no definite spurt, and since we have to allow for some wabbling in any individual's test scores, the best conclusion, up to date, is that the spurt is not proved (*1*). X

Whether, apart from the questionable spurt, the mental growth curve resembles that of physical growth in rising more and more slowly from birth to maturity, is a very difficult question to investigate. In our pride as adults, especially as young adults, we belittle the young child's intellectual attainments and assume that, of course, the greatest part

of mental development occurs in adolescence. But consider the achievements of the two-year-old. He can walk, talk, and manipulate objects skillfully. He has advanced from the animal to the human level in his first two years, and it is a fair question whether any later period of two years will show as great an advance. The gain from birth to two years is certainly striking. Is the gain from 12 to 14 as striking? Psychologists who have attempted to work out the mental growth curve are agreed for the most part in regarding the development of the first six years as at least half of the total advance from birth to maturity.

Badly misinterpreted, the Mental Age scale may seem to imply that the child gains as much in one year as in another; for does he not, on the average, gain one year of MA in each year of CA? Yes, but these year-steps of MA are not necessarily equal. They are simply the gains that the average child makes. To use them in tracing the growth curve would be reasoning in a circle. It would amount to saying that the child gains a year per year. In order to measure growth the psychologist attempts to devise scales graduated in equal steps of difficulty or intellectual altitude, and when such scales are approximated, the mental growth curve is not unlike that for physical growth. The gain decreases gradually from year to year, but continues in some intelligent individuals even into later adolescence (*44*).

Mental growth and decline during adult life. Common opinion would probably be that intellectual ability increases to middle life and declines in old age. Intelligence test scores, however, show a declining tendency from the age of 20-25 on, the decline being very gradual. This decline has been noted by several investigators who have tested large samples of the various adult age groups (*13*, *23*, *45*). These investigators have taken great pains to secure comparable groups at the different ages. In a California study, age groups of equal educational and social status were tested, with results shown in Fig. 29. In a New England study, practically the entire population of certain rural districts and small towns was tested, with results shown at the bottom of

Fig. 30. In this last Figure a contrast is seen between the scores in tests dependent largely on knowledge, and in tests demanding alertness and flexibility. The *knowledge curve remains practically level* from 20 to 60 years of age, while the *alertness curve drops off quickly* from its maximum at 17 years. In another large-scale investigation, learning ability was found to decline at a moderate rate from 20 on (*43*). In still other studies, old people have been found to

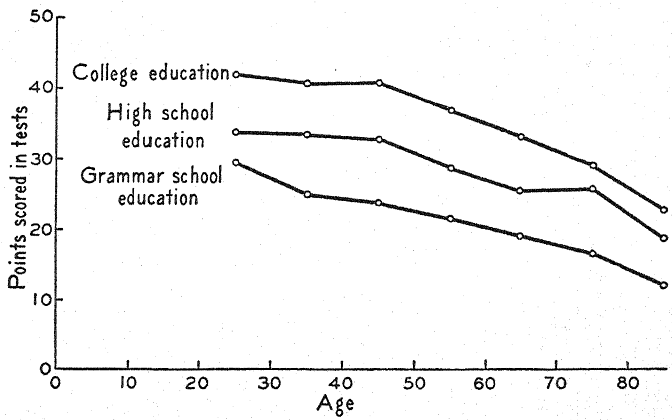

Fig. 29.—(Miles & Miles, *21*.) Age curves in intelligence test scores. Large samples were tested in each age group, and the individuals of approximately equal education were taken together in finding the averages. The decline with age is doubtless genuine, and not due to unfair sampling, since it appears in the college graduates, in the high school graduates, and in those with only grammar school education.

keep up very well in vocabulary but to be below the young adult standard in new learning and in quick perception and adjustment.

To avoid misunderstanding, it should be added that individual differences are great at every age. The members of any age group differ more among themselves than the average person of 20 differs from the average person of 70. A considerable number of the 70-year-olds surpass the 20-year average.

The adult can go on for many years, enlarging his knowledge and improving his technique in his chosen field and in his social life, and we usually think his "judgment" con-

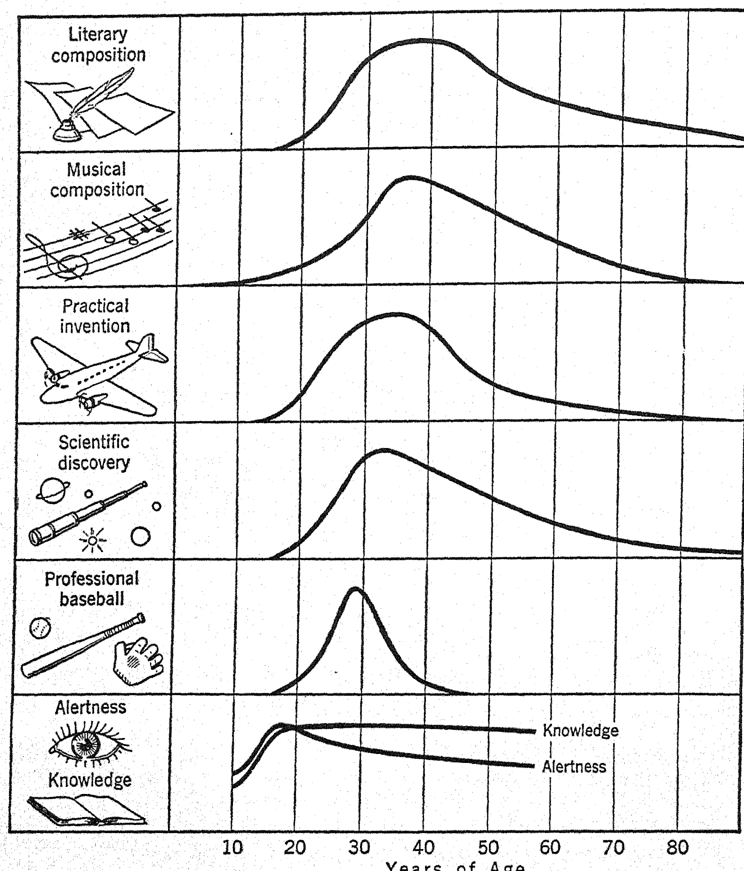

FIG. 30.—(Data from Lehman, *14*, *15*, *16*, *17*, and from Jones & Conrad, *12*.) Intelligence and achievement as related to age. The two curves at the bottom show the average scores of comparable age groups in the Army Alpha intelligence test (p. 108). The "Knowledge" curve shows the run of the scores in the sub-tests that depend largely on knowledge, while the "Alertness" curve shows the scores in the sub-tests that depend mostly on close attention and mental flexibility. The Knowledge curve stays up while the Alertness curve begins to sag as early as the twentieth year.

The other curves show the rise and fall of superior output in different lines. The uppermost curve is based on the number of great works produced by modern writers (now dead) at different times of their lives; their output was high from 30 to 45 years of age, without any sharp peak. The curve for baseball has a rather sharp peak at 25-30; that age scored highest in the number of major-league players, extra credit being allowed for champions in batting, pitching, and base-running. The peak for great scientific, inventive or musical output falls in the thirties.

tinues to improve. When we turn to the great achievements in science or art or in any line, we usually find the high point later than the twenties, though most of the great producers have demonstrated their superior ability by this time. Their early works are great but not so great as those they produce a little later. On the whole and with many individual exceptions the high point is reached in the thirties or early forties.

Maturation and use in the growth of intellect. In considering this topic let us start with old age and work backward. The decline of ability in old age can sometimes be laid to getting out of practice, i.e., to lack of exercise. But not always. The baseball player or the operatic singer continues intensive practice, yet his ability declines. The cause lies certainly in the biological process of aging, a process which starts early in adult life rather than on the verge of old age. Muscular strength and efficiency decrease after the twenties. The hearing of the very highest tones is lost even in the teens. The sense of sight declines somewhat later, but it does decline and certainly not from lack of use. The sex functions weaken sooner or later; the skin becomes thin; the hair loses its color; and there are many other changes incident to the process of aging (*24*). No one doubts the reality of biological aging, unless it be some theorist who is determined at all hazards to uphold the view that all growth is due to exercise and all decline, therefore, to lack of exercise. If he once admits that abilities decline because of the aging of the organism, he can be driven to concede that the growth of abilities is partly due to maturation.

It would be absurd to hold that intellectual development is wholly due to maturation. Maturation doubtless ceases in adolescence and the later gains in achievement must be due to use and learning. Throughout childhood and adolescence learning is actively going on along with maturation. They work together and their effects cannot be separated. We can believe that in adolescence, as in the development of walking and speech in the first year, function is made pos-

sible by maturation, and strengthened and made more efficient by exercise.

ARE DIFFERENCES IN INTELLIGENCE DUE TO HEREDITY OR ENVIRONMENT?

A similar question regarding the cause of individual differences in personality would be just as interesting, but our evidence is more ample in the case of intelligence. Much important work is being done on this particular question. The reader must not expect a categorical answer. Decisive evidence is hard to obtain, and probably the true answer, if we had it, would not be categorical enough to settle a bet or to quiet the age-long dispute between the hereditarians and the environmentalists.

Exposing individuals of the same heredity to different environments should make them differ, but the question is how much they would differ and in what ways. Exposing individuals of differing heredity to the same environment should not prevent them from developing differently, but again the question is how important the differences would be. Probably the differences found among the individuals in a community are due partly to heredity and partly to environment, but how large is the share of heredity and how large that of environment? The answer cannot be found by studying a community, because the hereditary and environmental factors are jumbled together. Some sort of experiment is needed.

The logic of investigation is the same as in the biological experiments discussed earlier in the chapter. The importance of heredity comes out when individuals of different heredity are reared and schooled alike; and the importance of environment can be estimated from the differences found among individuals of the same heredity when brought up in different environments.

Clean-cut experiments such as can be made on animals are scarcely to be expected with human subjects. We have to

be contented for the present at least with approximations to a true experimental setup.

It is easy to find children of different heredity, but how can we provide for them a uniform environment? Approximations to this condition are found in the family, the school, the orphanage; and we will inquire how much children differ in intelligence when brought up in these relatively uniform environments.

Some approximation to the other desired condition—same heredity but differing environment—is found in the following situations:

Identical twins brought up together or apart;

The same individual exposed successively to poorer and better environments;

and we will ask how much difference it makes to the children.

Families, schools and orphanages. These institutions provide a *somewhat* uniform environment for children of differing heredity. Children of the same parents—*siblings*, as brothers and sisters are called without distinction of sex—do not ordinarily get the same chromosomes and therefore differ in heredity, though they are more alike in this respect than children taken at random from the community. In the intelligence tests, siblings prove to be more alike than children taken at random from the community, but still they differ considerably. This result is what we would expect from heredity, but can we assume the home environment to be the same for all the siblings, so far as influences are concerned which favor or impede the development of intelligence? It would be a very doubtful assumption. Parents do not treat all their children alike, and the younger child has the advantage or disadvantage, whichever it may be, of starting life in a larger family. There are many subtle differences and we know little of their effects on the development of intelligence.

Besides, it can fairly be said that *each individual selects his own environment in large measure*, and that siblings of different heredity will select different environments. They

prefer different toys, companions, radio programs and reading matter, and so expose themselves to different influences. They are sure to be treated differently, for it is practically impossible to treat two persons alike if they differ in intelligence or personality. With the effects of heredity and environment combined as they are in the family, the differing intelligence of siblings is not conclusive evidence on either side of the question.

The children of a small, homogeneous community differ more than siblings in heredity, and they differ more in home environment. But they all attend *the same school* and have the same teachers, grade by grade. If we lay as much stress as the environmentalists like to lay on the importance of the school in developing intelligence, we shall have to say that all these children are exposed essentially to the same environment and that the large scatter of the IQ in such a group is due to heredity. In face of this argument the environmentalist retracts some of his emphasis on the school and points to the different home environments. Again, nothing is proved beyond dispute.

An *orphanage* may provide the experiment we wish to find. It takes in children of various parentage who differ more than siblings in heredity, while it provides an environment that is more uniform than the diverse homes of a community. We might expect the children brought up in one orphanage to be equally bright. As a matter of fact, they differ in brightness almost as much as the children of a community, and this is true even when they have been taken into the orphanage at a very early age. The orphanage certainly does not wipe out individual differences. This result would seem to dispose of the view of the extreme environmentalist who believes that all individuals are equal in native capacity and that differences in intelligence are wholly due to environment. He can properly criticize the experimental setup, however. He can say that no more than the private home is the orphanage an absolutely uniform environment for all the children (*46*).

The evidence so far shows that individuals of differing

heredity differ in intelligence in every environment that has ever been tried. There is no evidence whatever that uniform environment wipes out individual differences. We can reasonably assign some importance to heredity. To test the importance of environment we must turn to situations in which heredity is not a factor, i.e., in which individuals of the same heredity are exposed to different environments.

Twins, identical and fraternal. Though siblings do not generally have the same heredity, certain pairs of twins form an exception. It sometimes happens that two individuals are derived from a single fertilized ovum, because of a splitting of the embryo at a very early stage of development. Since all the cells derived from a given fertilized ovum have the same chromosomes, two such individuals have identical chromosomes, identical heredity. At birth they usually resemble each other so closely as to be barely distinguishable, and their physical resemblance becomes more striking rather than less as they grow up. These are the unioval or *identical twins*.

The majority of twin pairs, called *fraternal*, are not especially alike and are twins simply because two separate ova were fertilized (by two spermatozoa) at practically the same time. Coming from different fertilized ova, fraternal twins have different sets of chromosomes and have no more in common, so far as heredity is concerned, than can be expected of any two children of the same parents. Fraternal twins are as often of unlike as of the same sex, while identicals are necessarily of the same sex, since sex in the human species is determined by the chromosomes.

Identical twins, when tested, prove to be much more alike in any ability than fraternal twins. The degree of resemblance can be indicated by the correlation measure, used so as to show how closely the score of one member of a pair agrees with the score of the other member (p. 69). The higher the correlation the closer the resemblance. With regard to intelligence (and to standing height for comparison) the following table gives the net result of many investiga-

tions. To avoid sex differences, all twins or siblings compared are of the same sex.

CORRELATION BETWEEN

	Identical Twins	*Fraternal Twins*	*Siblings*
Standing height	.93 to .95	.50 to .65	.50
IQ	.90	.63 to .70	.50 to .60

The resemblance between identicals is much closer than between fraternals who however are somewhat more alike than siblings in general. The same fact appears in another way when the difference in IQ is found between the members of each pair of identicals, between the fraternals, and so on. The net results to date are about as follows:

AVERAGE DIFFERENCE IN IQ POINTS BETWEEN

Identical Twins	*Fraternal Twins*	*Siblings*	*Unrelated Individuals*
5	9	11	15

We see that the identicals differ no more from each other than the *same individual* commonly differs from himself in repeated tests (p. 117). There is nothing in the averages to show that identical twins really differ *at all* in intelligence, though they doubtless do in some cases. The results shown conform very well to what would be expected from heredity alone, except for the fact that fraternals are a little more alike than siblings in general. Since fraternals probably have no more heredity in common than other siblings, their closer resemblance must be an effect of environment. Fraternals have more environment in common than most siblings, being exposed simultaneously to the same home and school influences. And the environment is more alike for identicals than for fraternals, because two children who are hardly distinguishable will be treated more alike than any other children can possibly be. So the environmentalist will say that the

results conform perfectly to his theory: the environment differs least for identicals, next for fraternals, then for siblings, and most for children in different families; and the intelligence differences correspond. The data so far considered do not enable us to throw out either of the rival theories.

Identical twins reared apart. For a really decisive experiment we should arrange to have identical twins brought up in radically different environments. An approach to such an experiment would be to find identicals that had been separated in early childhood and brought up in different homes. By the strenuous efforts of investigators at least twenty such pairs have been discovered in the United States and Canada, their physical identity verified and their abilities sampled by a number of standard tests (*29*). In several instances the twins, being adopted very early, grew up in total ignorance of each other's existence and only discovered each other because their close resemblance had attracted someone's attention.

In most of these cases the foster homes did not differ very greatly in intellectual level, but in a few cases one twin had much more schooling than the other. One girl went through college while her twin had only two grades of the elementary school. This pair showed the largest difference in IQ, the better educated young woman obtaining an IQ of 123 and the other only 98 though she, too, was successfully holding a rather intellectual job. Four other pairs had quite unequal schooling and three of them showed corresponding IQ differences. On the face of these returns, a fairly large IQ difference can be produced by a fairly large difference in education.

Aside from these five cases of very unequal education, the remainder of the separated identicals were remarkably alike, twin for twin. They differed no more than identicals reared together, 5.5 points IQ on the average. Merely being brought up in different homes has little effect on identicals, as appears clearly from the distributions in Fig. 31.

At first glance an environmentalist is satisfied with the

results, for he says, "The larger the difference in environment, the larger the difference in intelligence." On second thought he is not so well pleased. He would like to believe that the differences in intelligence found among the children attending the same school from a community of average

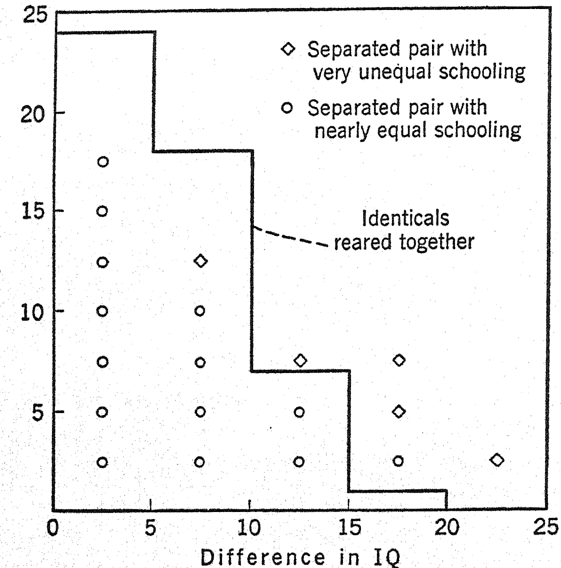

FIG. 31.—(Data from Newman, Freeman & Holzinger, *27*.) IQ differences between identical twins, reared together or apart. The stairlike figure shows the distribution of differences found between identicals reared together, and the dots show the same for identicals reared apart.

homes are due to the relatively small environmental differences affecting the children. He would expect, then, that identicals reared apart, even though not subjected to radically different homes or schooling, would differ about as much as children taken from different homes in the community. He would expect an average IQ difference of 15 points instead of 5.5, the latter being practically no difference at all since it is commonly found between test and retest of the same individual.

The sample of identical twins reared apart is still too small to justify confident conclusions. Subject to this qualifica-

tion the indicated conclusions are two. (1) Differences in environment and especially, so far as the evidence goes, differences in education, can produce differences in tested intelligence. (2) This environmental-educational factor, by itself, is not nearly powerful enough to account for the differences actually found in the community.

Raising the IQ by improving the environment. One sure way to keep heredity constant is to expose the *same individual* successively to different environments. If we could transfer a group of children from a poor to a more stimulating environment we ought to raise their IQs. The only question would be *how much* we could accomplish in this way.

Progressive schools aim to conduct just such an experiment, in the belief that the traditional home and school environments do not allow scope for the full development of the child's intellectual powers, especially of independent thought and creative activity. In some such schools intelligence tests have been given at intervals and the results examined to see whether the children's IQs were rising. Commonly a small rise, as of 3-6 points, is found over a period of years. Possibly the rise would be larger if the children did not come from such good homes. Their homes may have been as adequate at the preschool age as the excellent school is at school age. But it might be possible to improve the preschool environment of most children, by providing well-chosen materials and the companionship of other children under expert supervision. Such an experiment is the *nursery school.* When the results are checked up, an average gain of as much as 10 points in IQ is reported from certain nursery schools, but most of them are more modest in their claims. Exactly what type of nursery school environment is best adapted to the intellectual needs of the little child has not been worked out and will probably require a good deal of experimenting. In stimulating his intellectual growth we must not neglect his emotional needs; the nursery school may indeed accomplish more for his personality than for his intelligence.

A good experiment would be to take a group of young children from a barren, unstimulating environment, give them the advantages of a good nursery school and see whether their intellectual status was definitely raised. A well-planned experiment of this sort was undertaken in an orphanage where the children were kept in good health but with very little attention to their mental development. The adults in charge were so few and so busy that the children heard little speech and were quite retarded in speech development. They had little play material and little opportunity to get acquainted with the environment. In the grounds of this orphanage a well-equipped and expertly staffed nursery school was set up. A group of young children was taken into the school and a control group, matched in IQ, child for child, with the nursery school group, was left in the regular orphanage environment. The plan was to follow the two groups along for three years, which should be time enough to bring out the effects of the two contrasting environments. Unfortunately the experiment broke down for humanitarian reasons. When a child of either group had a chance for adoption into a good home, it did not seem fair to hold him in the experimental situation. Consequently both groups were constantly being depleted, and though their places were filled by substituting other children, the nursery school did not have a chance to exert its influence on the individual child over a long period. The results were by no means clear, but the indications were that a year in the nursery school, as contrasted with the orphanage environment, gave the child an advantage of about 5 points in IQ (*36*).

Foster children. Another good experiment is to remove children from inferior homes and have them adopted into superior homes, so as to see whether the IQ rises. The orphans and other dependent children who come into the hands of child-placing agencies are in the main from relatively inferior homes, and are placed in relatively superior homes since the agency is careful to select foster parents who are prepared to take excellent care of the children.

Children adopted when over two years old, in a large sample from Michigan (*30*), ranged in IQ from 50 to 150 with an average of 98. (Children known to be feeble-minded or of very inferior parentage are not usually offered for adoption, out of consideration for the foster parents.) Those retested after adoption gained 6 points IQ on the average, and the same average gain was found in another sample from Iowa, adopted from an orphanage at 2-5 years of age and having an average IQ of 98 before adoption (*37*).

Children adopted very soon after birth have been studied in several large samples. From what is known of their own parents, the expected average IQ of these children would be not far from 100. Actually, after several years in their foster homes, the average was 104 in a Chicago sample, 107 in a California sample, and 110 in a sample from Minnesota. In a Toronto sample, all the own mothers were tested and found to have an average IQ of 84, from which (because of the usual parent-child correlation of +.50) the expected average IQ of the children would be about 92, instead of the actual average of 98 in tests given some years after adoption. The results all agree very well and indicate a gain of 5-10 points IQ on the average as the result of transferring a young child from an inferior to a superior home environment.

No matter how much emphasis we may be inclined to lay on heredity, we could look with complacency on much greater changes than these. When knowledge of the effects of environment has advanced far beyond its present state, our successors may be able to raise the mental ability of the whole population by the equivalent of 25 or 50 points IQ. But this improvement will not eliminate individual differences nor necessarily diminish them at all. Differences in heredity make themselves felt in any environment, no matter how superior. So far as concerns the scatter of intelligence now existing in the population, the known effects of environment account for only a small part of it. Probably the major part of it is due to that intimate combination of heredity and environment suggested by the statement that each individual

tends to select his own environment to suit his own heredity (*5, 11, 15, 30, 37, 39*).

HOW UNIFORM ABILITY AND BEHAVIOR ARE PRODUCED

When the effects of heredity and environment are scrutinized, the interest usually lies in differences between individuals, races and other groups. But the degree of sameness existing in any group also demands explanation. Let us consider for a moment what makes people so much alike.

According to all our previous reasoning and evidence, individuals of different heredity are not made alike by exposure to equal environments. In order to make them equal in ability we should have to *compensate* for the greater capacity of the one by giving the other more stimulation, better training.

Compensating or regularizing influences. If the environment is to make individuals more alike in ability, i.e., to prevent differences in native capacity from manifesting themselves, it must somehow make it impossible for the greater capacity to develop. One way would be to avoid all opportunity for developing a certain capacity. If one child had almost zero capacity for music, and another child great capacity, they could be kept equal in musical ability by excluding all music from their environment. Another way would be to enforce certain very moderate standards, as is often done in school. The children in a certain school grade were tested in October on the work to be covered during the school year and were found to be very unequal in their advance knowledge. They were tested again in May on the same subject matter and found to be much more nearly equal than in October. During the year they had all been taught by the same teacher and had seemingly been exposed to the same environment. But this semblance of sameness disappears when we find that some of the children mastered the required subject matter early in the year, and others not till late in the year. The teacher was enforcing the usual

moderate standards of achievement for the grade, laboring with the laggards and thankful that the bright ones needed no prodding. In schools that leave each child free to advance at his own pace, individual differences come out very strongly (p. 123). Free, unlimited opportunity favors individual differences, while restricted opportunity tends toward regimentation of abilities. In many ways the social group sets up quite moderate standards of conduct and enforces conformity with the standards by using pressure where it is needed. Unequal environmental pressure compensates in some measure for differences in native capacity.

Regimentation operates on personality traits as well as on abilities. George, let us say, is inclined to be overactive and boisterous, and his parents try to calm him down. His brother John is almost too quiet and they try to stimulate him. So the two boys are brought somewhere near a uniform standard of motor activity, at least in the house. In other places and conditions their natural tendencies may continue to manifest themselves. In a group of playmates, Mary is ridiculed for excessive timidity while Ruth is criticized for taking foolish risks, and so the group brings its members toward a common standard of overt behavior, though the natural tendencies may still persist and create different personal problems for different individuals.

One's personal problem is not entirely that of avoiding criticism by conformity with the group code. On the positive side, one desires to make a role for oneself, so as to count for something in the life of the group. Here individual differences are an asset rather than a liability, for different roles call for different abilities and different personal traits.

SEX DIFFERENCES, DUE TO CONSTITUTION OR TO CONVENTION?

No elaborate investigation is needed to reveal the fact that men and women in our society differ in occupations and special abilities. When psychologists have investigated the matter (*42*) they have found characteristic sex differences in

such matters as information, opinions, interests, likes and dislikes. The masculine interest favors outdoor adventure, the feminine favors domestic and social activities. The male student has more general information on scientific matters, the female on matters of taste, literature and art. The women give expression to more pronounced pity, disapproval, disgust, fear and even anger than the men. Whether men are more aggressive and dominant may be doubted, since women dislike being blamed or snubbed, like to have their own way, are sometimes bossy, and sometimes make excellent executives. Serious mistakes are often based on the assumption that a woman is always pleased to have the man dominate.

How far such sex differences are biologically determined, and how far they are merely traditional (though deeply ingrained, no doubt) cannot be known from observation of our own culture alone. Anthropologists have discovered tribes in which the men take a large share in caring for the babies, or in which the women are the businesslike providers while the males play an artistic and decorative role (*22*). Such a differentiation is not unknown in young households in our own culture, especially during economic depressions when the wife alone may be able to find a job. In every culture individuals differ in their aptitudes and natural inclinations.

Sex itself is determined by heredity. Of the 48 human chromosomes, there is one which determines the sex of the individual. It occurs in two alternative forms, one giving rise to male gonads, the other to female. Any sex difference produced by the male and female hormones is attributable to heredity, to native constitution. The gonadal hormones are responsible for the male and female plumage of birds and for certain physical differences between men and women, in size and build, hairiness, voice and other secondary sex characteristics.

Probably due to heredity is the typical difference between men and women in muscular strength. Man surpasses not so much in endurance as in intensity of muscular action. He can squeeze harder and punch harder and run faster. This

difference is not due simply to occupation, since it is present even in tribes where women do most of the hard labor. Men's muscles use fuel and oxygen more rapidly, and their red blood corpuscles, which carry the oxygen from the lungs to the muscles, are 10 percent more abundant than those of women.

Another hereditary difference comes to light in the earlier maturing of girls. They reach sex maturity and adult stature a couple of years sooner than boys. Their interests along in the early teens are more mature than those of boys of the same age.

We have then a difference in size and muscular strength favoring the men and a difference in early maturity favoring the women. Adding the obvious difference in reproductive functions we have perhaps the full list of strictly hereditary sex differences. These few biological differences affect the occupations and achievements of men and women in many ways. Man's love for outdoor adventure is almost certainly dependent on his muscular strength, and woman's love for everything domestic stems from her maternal function.

It is important to remember that sex differences in behavior and achievement are merely *average* differences and that the male and female distributions overlap. Even in stature, though men average two or three inches taller, many individual women are taller than the male average and many men shorter than the female average. The same overlap is found in muscular strength. In the more intellectual performances the sex difference is small in comparison with the range of variation within either sex.

The main intellectual differences that have been found by use of tests are that girls excel in verbal or linguistic ability, boys in mechanical and spatial ability.

Girls and women surpass in various language tests, such as vocabulary, opposites, sentence completion, color naming, or saying all the disconnected words possible in three minutes. Girls seem to have a definite advantage in all sorts of language activity. As babies they begin to talk a month earlier than boys, they pick up words more quickly, and they use longer

sentences in the early years. They hesitate and stutter less than boys. In school they outdo the boys in language work. No one has suggested any reasonable environmental explanation for this sex difference.

Boys surpass in many motor tests, though decidedly not in handwriting. Their superiority in managing mechanical contrivances is as marked as the girls' superiority in language. The spontaneous, eager interest of boys in tools, building materials and mechanical toys is far beyond that of girls. Everything looks like a native sex difference. To make sure, we should see to it that boys and girls have the same environmental influences with respect to this kind of play. The girls must not be given to understand that this is boys' play; they must not be cautioned more than boys against the dangers of hammers, knives and saws. Such equality of treatment is approximated in some nursery schools, and yet the boys play with blocks and trains much more than the girls. Of the traditional male professions, women seem to have less inclination for engineering than for law or medicine. If there is a native sex difference here, it is probably tied up with the difference in muscular strength.

On the whole the sexes are about on a par intellectually. They are certainly much more nearly equal than our ancestors believed. Biology gives no ground for expecting large differences, and tests do not reveal any.

One intriguing question cannot as yet be answered—the question why the great geniuses and producers, and the great scoundrels and criminals, are still predominantly men in spite of the increased freedom of women. One theory is that the male sex is inherently more variable and so furnishes the extreme deviations from the average, both in the desirable and in the undesirable direction. Another theory goes back to the male advantage in red blood corpuscles, oxygen consumption and muscular force, and supposes that men are capable under stress of putting more energy into their activity. Still another theory is purely environmental and believes that eventually the female sex will fully equal the male in output of geniuses and criminals.

Final word on heredity and environment. From all the evidence it is reasonably certain that both heredity and environment are potent factors in causing human beings to differ in ability and personality. The evidence for heredity is the observed fact that individuals do differ in every tribe, in every family, in every school, in every occupation, and after any amount of training. The chief evidence for environment is the highly important fact that individuals *learn*, what they learn being obviously dependent on what the environment has to offer. While awaiting the final decision of science on the relative importance of heredity and environment, it is wise to allow considerable importance to heredity. It is wise for society to take measures to perpetuate the best family stocks, which have a tendency to die out from their low birth rate (7). As things go today the more successful people have the fewer children. In animal breeding that would be very poor policy, and in the human stock also a gradual decline would appear inevitable if the most promising lines are continually permitted to die out. And here is another point to consider. Whether by heredity or by early environment, it certainly is the parents that give the child his start in life. The children of feebleminded parents have a poor chance in life, and society may well take measures to minimize the number of such children. The children of intelligent and well-adjusted parents have the best start in life, and the proportion of such children should be kept as high as possible. The next generation has a just claim on the present generation to provide it with the best parents available.

Summary of the chapter. Heredity and environment are studied first as factors in development and then as causes of individual differences. All development depends on their combined action, but individuals differ sometimes because of differences in heredity and sometimes because of differences in environment, as is well shown by certain biological experiments. Development is neither an unfolding of heredity without influence from the environment nor a process of being passively molded by the environment. It consists of active responses by the organism to environmental forces.

Some development, which we call maturation and which includes the differentiation of the embryo into an organism with its diverse organs, depends only in a general way on the environment and is controlled mostly by the interaction of parts within the partially developed organism. Other development results from the activity or use of the organs. Such activities as walking and talking depend first on maturation and then on activity. Intellectual and personality development probably depends in part on maturation, and certainly in large measure on activity and learning. Differences in intelligence are shown to depend in some slight degree, at least, on the stimulation received from the home and school environment, but most of the variation of intelligence in the population remains unaccounted for unless it be by heredity. Intellectual sex differences are slight and are largely dependent on social custom, but the most striking, like the girl's superiority in language and the boy's in mechanical interest, may depend on heredity.

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Intelligence: Its Nature and Nurture is the title of the Thirty-ninth Yearbook of the National Society for the Study of Education, a two-volume work published in 1940. It consists of original articles and critical reviews by a large group of psychologists. This important source book affords a "panoramic view of what is going on" in this active field of investigation. It treats of foster children, the effects of nursery school attendance, and other evidence bearing on heredity and environment in relation to the intelligence of children. Significantly, the very competent committee in charge of the whole enterprise found itself altogether unable to reach a consensus of opinion, or to offer any authoritative pronouncement that should settle the question. Taken as a whole, the evidence presented is certainly not opposed to the conclusions reached in the foregoing chapter: (1) that a moderate raising of the IQ can be achieved by improvement of early environment; (2) that the demonstrated effects of environment fall far short of accounting for individual differences as we find them today; and (3) that absurdly little is known as to environmental influences favorable or unfavorable to the development of intelligence.

Chapter VIII

The Nervous System

AT THIS point in our journey it will be well to pause and take our bearings. For several chapters our main quest has been individual differences and their causes. Before that we sketched in outline the other main part of our study, concerned with ways in which individuals are alike. Now we return to this line. To be sure, in considering ways in which people differ we have noticed that they differ in degree rather than in kind. They do not fall apart into separate types or into a bimodal distribution. They all have some degree of verbal, numerical, spatial and other abilities, they are all able to use past knowledge to some extent in dealing with a novel situation, they all have some ability to grasp relationships. So we have incidentally taken note of several ways in which people are alike. They are more or less alike also in personality traits, and are all affected by glandular and social influences in their behavior. From this point on, individual differences will be in the background—for nowhere in psychology can the fact be neglected that individuals differ—but the emphasis will be on learning, thinking, desiring and other fundamental processes.

We commence this side of our study—or continue it, since the section on development in the preceding chapter is really a study of universal processes—by some consideration of the role of the nervous system in human activity. It is a dip into physiology not particularly welcome to some readers who would be quite willing to consider the individual's relations to the world and the social group without concerning themselves with what goes on inside the individual. Yet,

after all, the individual is an organism, not a disembodied spirit. When he sees, learns, thinks or desires, he is using his nervous system, as well as his receptors and muscles, and if physiology can tell us anything helpful in understanding these processes, it would be a pity not to listen. For a century and more, not a few great physiologists, anatomists and clinicians have occupied themselves with the nervous system, hoping to throw light on behavior, and have accumulated a vast treasure of knowledge. The trouble with this knowledge is its remoteness from our ordinary range of ideas. Though nothing is closer to you than your brain, nothing seems more remote than its intimate structure and mode of operation. Much of the detailed knowledge is not especially helpful at present to psychology, but a few basic facts are at least very interesting, once you put your mind to them.

This study of the nervous system ties up closely with our early discussion of stimulus and response, and with later chapters on the senses. In connection with individual differences, the question most likely to arise concerns the relation of brain size to intelligence. Some individuals of outstanding ability have been found, on postmortem examination, to have had very large brains, and some idiots very small brains. But the relationship is far from close. Brain size (as judged from head measurements of living individuals) and intelligence (as tested) give a correlation of only +.10 or +.15, indicating that individual differences in intelligence are accounted for only to a very small extent by differences in the mere gross size of the brain. Other factors such as the fineness of internal brain structure and the chemistry of brain tissue are probably more important.

We approach the physiologist for information bearing on such questions as these: how the organism, for all its multiplicity of parts, is able to act as a whole; how, being a unit, it can still act in so many different ways; how it responds to stimuli; how it selects and combines—for we saw that selectivity and combination were very characteristic of both the reception of stimuli and the execution of movements; how it maintains a set toward a goal through a series of acts; and

how it builds up and holds a "situation set." Looking ahead to later chapters we should hope that physiology would throw some light on learning and retention and on the sensory processes. Even if we do not get neat, confident answers to all our questions, we shall see them from a new point of view.

UNITY AND VARIETY OF RESPONSE

Going back to first principles we see that individuals are alike in the general problem they have to solve, the problem of dealing effectively with the environment. Such dealing is dependent on the receptors and effectors, the receptors receiving stimuli from the environment, the effectors (muscles, particularly) producing changes in the environment. The receptor cells are very numerous (millions of them in the eyes alone), and the muscles are composed of very numerous muscle fibers. All this contact with the environment would be of no use to the organism unless there were some connection from the receptors to the effectors. The muscles must react to stimuli received by the receptors, and in an emergency the reaction must be quick. Rapid communication from the receptors to the effectors is provided by the *nerves*, which conduct so rapidly (about 75 yards per second) that they consume only a small fraction of a second in a simple reaction (p. 30).

How the organism is enabled to act as a unit. A general view of the nervous system (Fig. 32) shows nerves ramifying to every part of the body; they really divide into much finer and more numerous branches than the figure shows. They supply every muscle and every receptor. But a second glance shows that these parts are not connected directly with each other but only with a central mass consisting of the brain in the head and the spinal cord extending down the back. All the nerves lead to or from this general nerve center. The "sensory" nerves, supplying the receptors, conduct into the center; the "motor" nerves, supplying the effectors, conduct out from the center. The sensory nerves report to the center, while the motor nerves take orders from the cen-

ter and in turn arouse activity in the muscles. Thus the organism is centralized and capable of unified action.

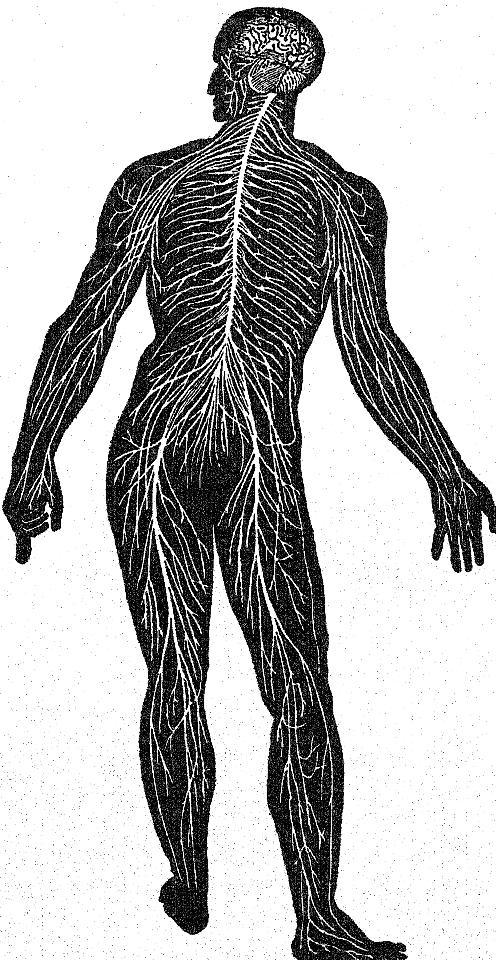

FIG. 32.—(Martin, *11*.) General view of the nervous system, showing brain, spinal cord and nerves.

How variety of action is possible. It is just as important for the organism to do different things under different conditions as for it to act as a unit. If the nerve center were simply a big reservoir receiving stimulation from the sensory nerves

and pouring it out into the motor nerves, every act would be a general spasm. Microscopically examined, the nerve center proves to be anything but a mere reservoir. It has a very intricate structure. Even a single nerve consists of many minute fibers. The largest nerve in the body, the

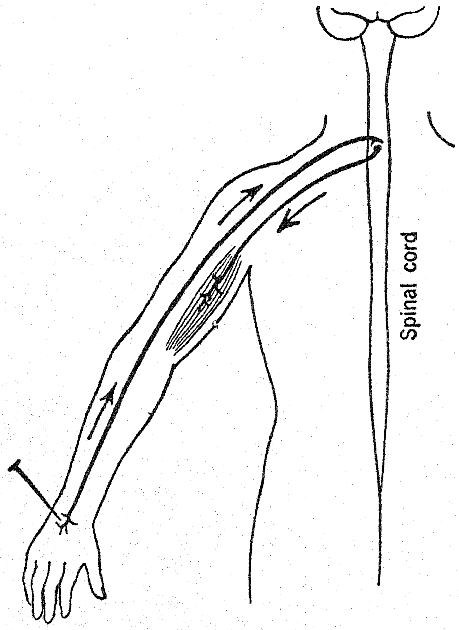

FIG. 33.—Nerve connection from the back of the hand, which is receiving a stimulus, to the arm muscle which executes the response. The nerve pathway leads into the spinal cord and out again.

optic nerve conducting from the eye to the brain, contains as many as 400,000 fibers. Nerve fibers are extremely slender, but some of them are a yard long, each being long enough to reach from some receptor to the nerve center, or from the center to some muscle. These fibers are conducting units like the insulated wires in a telephone cable. Each sensory nerve fiber runs from a receptor to some definite part of the nerve center and each motor nerve fiber runs from some part of the nerve center to a particular muscle. The conduction along any sensory or motor nerve is not diffuse in the least but entirely localized and specific. The

structure of the nervous system is somewhat like that of a city telephone system. The nerves are like telephone cables in being bundles of insulated conductors, each conductor leading to a separate point outside of the center but all converging to a common center where connections are made. But the connections made in the nerve center are very different from those in a telephone central. One incoming call is switched to a selection of the outgoing lines and many in-

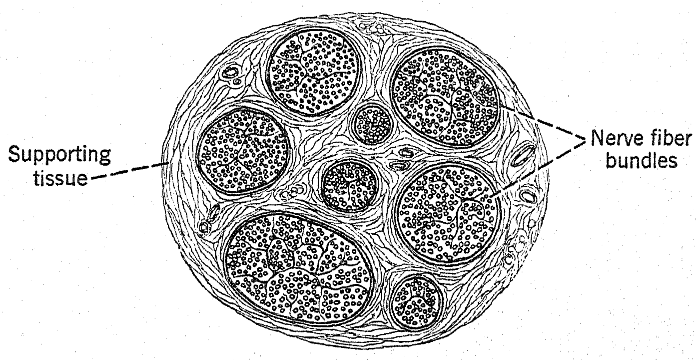

FIG. 34.—Cross section of a small nerve. It consists of several bundles bound together by supporting tissue. Each bundle contains many nerve fibers, showing in cross section as little dots.

coming calls may be switched to the same outgoing line. Thus the organism acts as a whole even while acting in a thousand different ways.

If the nerve supplying a muscle is broken or cut in an accident, the muscle is helpless. Receiving no stimuli from its nerve it remains inactive, paralyzed, and is likely to atrophy from disuse before the nerve regenerates. Similarly if one optic nerve is cut the person is blind in that eye. No stimuli can reach the brain, no messages, because with the nerve cut there is no means of communication from the eye to the brain.

Nerve cells. If we wish to know how the nervous system operates, there is little to learn from the mere gross appearance of the brain, cord and nerves, just as we could learn little of the operation of a telephone system by inspecting the cables strung along the street and the building housing

the central exchange. We need to examine the internal structure of the system, the microscopic structure in the case of the nervous system.

A *neuron* is a nerve cell including its branches. The whole nervous system is made up of neurons along with supporting tissue and the necessary blood vessels. Most nerve cells have two kinds of branches, a single *axon* and many *dendrites*. The dendrites are short tree-like branches, while the axon is very smooth and slender and may be several feet long (Fig. 35).

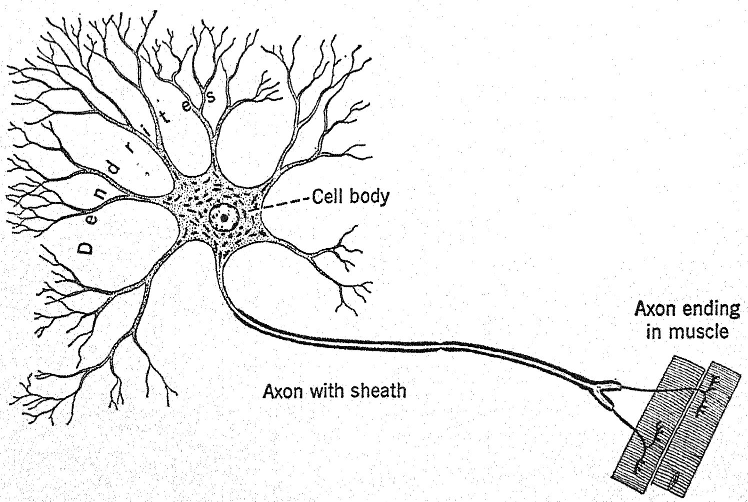

FIG. 35.—A motor neuron from the spinal cord, highly magnified. It has many dendrites, and a single axon that extends out to a muscle and there divides and makes close contact with a few muscle fibers. The axon is relatively much longer than shown in the figure.

Each nerve fiber contains an axon surrounded by an insulating sheath. The axons of the motor nerves are branches of nerve cells situated in the brain or cord. Each of these motor axons extends from some part of the brain or cord out to a muscle (or gland). Being stimulated in the nerve center it passes the stimulation along to its muscle (Fig. 36).

The axons of the sensory nerves are branches of nerve cells lying outside of the nerve center. Thus the axons of the optic nerve come from cells in the retina, the light-sensitive

part of the eye (p. 474), and extend into the brain. The axons for the sense of smell are branches of cells in the nose. The axons of the other sensory nerves are branches of nerve cells which lie in little bunches close to the brain or cord, and which are exceptional in having no dendrites. Each of

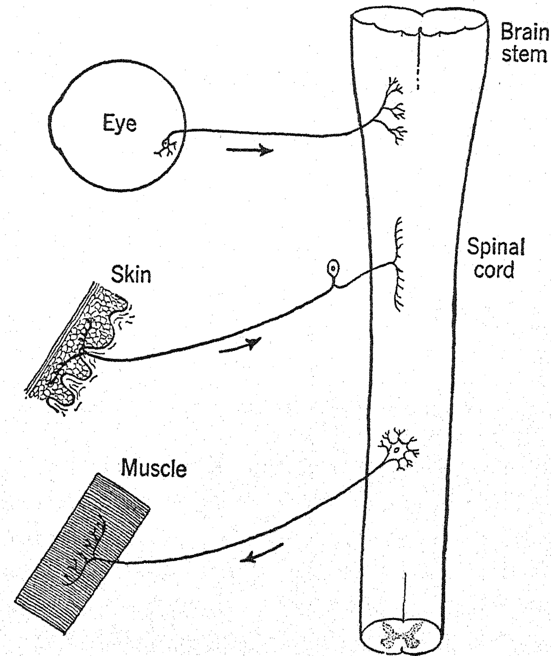

FIG. 36.—Sensory and motor axons and their nerve cells. The arrows show the directions in which the several axons conduct.

these axons divides and extends outward to a receptor in the skin or elsewhere and inward into the cord or brain, so providing a path of connection from that receptor to the nerve center.

The synapse. Variety of response is made possible by the peculiar mode of connection between neurons. Going back into the embryonic stage of development, long before birth, we find that the neurons begin life as separate, round cells. A little later they take on the character of neurons by sending out an axon and dendrites. Though they establish close

contact with each other by these branches, they never grow together, but each neuron always remains a separate cell. This form of connection, by contact only, is called synaptic connection and the contact between one neuron and another is called a synapse.

For simplicity let us first consider just two neurons and their synaptic connection. The axon of one neuron terminates in fine branches which interlace with the dendrites of the other neuron or attach themselves to its cell body. The

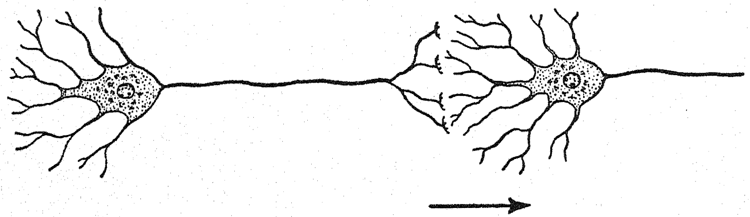

FIG. 37.—The synapse between the two neurons lies above the arrow. The arrow shows the direction of conduction across the synapse.

contact between the two neurons is close enough to enable one to stimulate the other. Communication across a synapse is always in one direction, from the axon of the first neuron to the dendrites or cell body of the other. The axon is a conductor and stimulator, the dendrite a receiver (Fig. 37).

One misconception that might be created by our simplified diagram should be corrected at once. The neurons are not linked up in single chains. Each axon terminates so as to establish synapses with several other neurons; it can deliver stimuli to any or all of them. Each neuron also receives stimuli from the axons of several neurons. We see the principle of combination coming in here in two forms: combination of stimuli upon a single neuron, and combination of elementary responses by an axon branching and stimulating several neurons. We will say more of these two forms of combination later.

The principle of selectivity also comes in, for the axons do not run at random and form synapses with any chance neuron. The sensory axon from a certain bit of skin runs to a

certain part of the spinal cord and connects with a certain group of neurons; and the motor axon from a certain part of the cord runs to a group of muscle fibers in a certain muscle and stimulates those particular fibers. The neuron connections are extremely intricate but highly organized.

The nerve current. When a sensory nerve fiber is stimulated, say in the skin, it swiftly transmits a message to the cord or brain. When a motor neuron is stimulated in the brain or cord it swiftly transmits a message to a group of muscle fibers which thereupon contract. What are these "messages"? What does the nerve conduct or transmit? We call it the nerve current, or nerve impulse, and as far as known it consists of electrochemical waves in the nerve fiber, very weak, consuming very little energy, but capable of arousing a muscle or a nerve center to action.

The all-or-none law in nerve and muscle. The meaning of "all or none" is illustrated by reference to a charge of dynamite. If the charge explodes at all it explodes completely. You cannot graduate the force of the explosion by varying the force of the spark with which you set it off. The charge can differ in amount, but whatever amount is present explodes as a unit. The all-or-none law holds good of the single muscle fiber and of the single nerve fiber. At any instant a muscle fiber contains a certain charge of available energy and any stimulus which arouses the muscle fiber to discharge uses up all this energy. In a fraction of a second the muscle fiber recovers, and has a new charge ready. Similarly a single nerve fiber discharges all of its available energy when it discharges at all. A stimulus may be too weak to arouse the fiber, but if it is strong enough to arouse any response it arouses the full response of which the fiber is capable at that particular moment (*1*).

Varying strength of response. A stronger stimulus to the organism usually brings a stronger response. A stronger light gives a stronger sensation of light, and a stronger effort gives a stronger muscular contraction. This gradation of response seems at first thought to be inconsistent with the all-or-none law.

There are two ways, in spite of the all-or-none law, in which a stronger stimulus can produce a stronger response. First, a stronger stimulus arouses a larger number of nerve fibers or muscle fibers. Even a pin point on the skin presses the endings of several sensory nerve fibers, and the more strongly it presses, the more nerve fibers will be stimulated. A weak nerve current reaching a muscle will arouse only a few muscle fibers, a stronger current will arouse a larger number.

In the second place, a stronger stimulus though it cannot increase the strength of a single discharge can arouse more discharges per second. The nerve fiber is so quick that a single wave of action is finished in a small fraction of a second. A continued stimulus applied to a nerve fiber arouses a series of response waves, and the stronger the stimulus the quicker the succession of response waves. In a single nerve fiber there may be as few as 5 waves per second or as many as 200, depending on the strength of the stimulus. Muscle fibers, too, discharge a smaller or larger number of times per second according to the strength of the stimulus received.

Putting these two factors together we see that the strength of a response depends upon the number of elementary discharges occurring per second, this number depending partly on the number of discharges in each fiber and partly on the number of active fibers. So we get graded sensations and graded muscular action.

THE STIMULUS-RESPONSE MECHANISM

When the axon of one neuron stimulates another neuron to activity, or when a motor axon stimulates a group of muscle fibers, we have stimulus and response in their most rudimentary form. One cell stimulates another. Such rudimentary responses make up the internal detail of behavior. Now take the organism as a whole: a stimulus is applied to a receptor and a muscle or group of muscles responds. What is the nature of these larger stimulus-response units?

Reflex action. In the "simple reaction" (which is not a reflex) the subject is told to be ready and then a stimulus applied to his ear sets up a nerve current to the brain; because of the way the brain is "set" the incoming nerve current quickly gives rise to an outgoing current down the cord and out to the muscles moving the hand; and the total reaction time is about .15 second (p. 59). This reaction is fairly quick, but the reflex wink of the eyelids in response to a touch on or near the eyes is quicker, taking about .05 second. Still quicker is the knee jerk obtained by striking the tendon just below the bent knee while the lower leg is hanging freely. The reflex time here is about .03 second. Not every reflex is especially quick, however, and some are slower than the simple reaction. The pupillary reflex, the narrowing of the pupil in response to a bright light suddenly shining into the eyes, takes a second or two.

All in all the organism is provided with many reflexes, most of which are useful. Further examples are the withdrawal of the hand from a burn or pinch, coughing, sneezing, and many internal reactions such as the movements of the stomach and intestines, and the widening and narrowing of the arteries which cause the skin to flush or pale. These are muscular responses, and there are also glandular reflexes such as the flow of saliva in response to a tasting substance in the mouth, and the flow of tears when a cinder gets into the eye.

A reflex is a direct muscular or glandular response to a sensory stimulus, an involuntary and unlearned response. Unlike the simple reaction, it does not depend upon the subject's being prepared or "set." The reflex does not need a "Ready" signal.

The reflex arc. The reflex depends on certain definite connections laid down in the growth of the nerve centers between the incoming sensory fibers and the outgoing motor fibers. The path from a sense organ through the nerve center to a muscle is called a reflex arc and some of these paths have been worked out in detail by physiologists.

A minimum diagram of the reflex arc shows the sensory axon leading from a receptor to the nerve center and there

forming a synaptic connection with the motor neuron whose axon extends out to the muscles (Fig. 38). This combination of a sensory and a motor neuron makes up a two-neuron reflex arc.

A three-neuron arc is the minimum diagram for breathing. Most reflex arcs have at least three neurons and some have more than that.

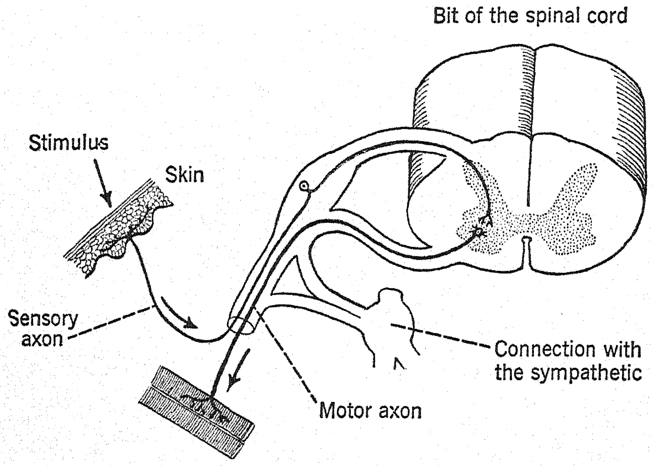

FIG. 38.–A two-neuron reflex arc. The "sympathetic" is of interest in a later chapter (p. 426).

These simple diagrams are instructive in showing some of the less complicated interconnections in the nerve centers and so giving us some idea of what to expect in the brain. They are misleading if taken too literally; they need to be supplemented by a few fundamental statements regarding nerve center activity.

1. Multiple nerve paths. Each single fiber in the diagrams stands for a whole company of fibers working abreast.

2. Converging paths. The single reflex arc does not ordinarily act in isolation from the rest of the nervous system. Every nerve center receives axons from several other parts of the nervous system and is thus subjected to a combination of influences rather than to one single stimulus. The breathing center for example receives not only sensory nerve currents from the lungs but also currents from many other sen-

sory nerves as well, so that breathing is easily modified by a painful stimulus, by a loud noise, or by a dash of cold water on the skin. The breathing center also receives nerve fibers from higher up in the brain, as we can infer from the fact that the breath can be hastened or slowed voluntarily. The

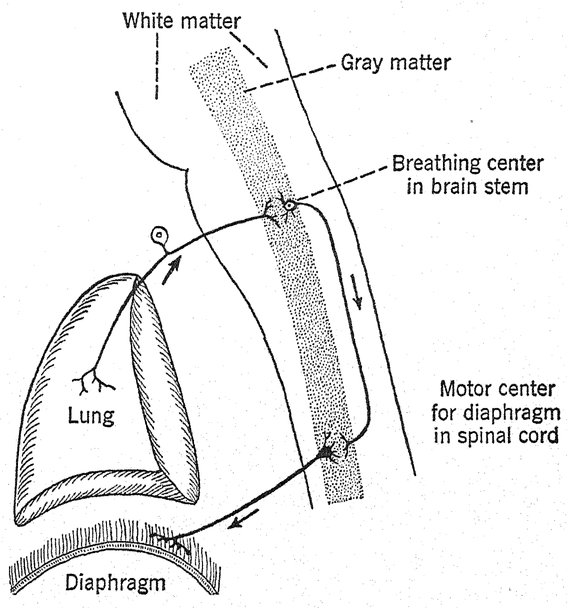

FIG. 39.—A three-neuron arc concerned in breathing. During expiration the sensory nerves of the lung are stimulated and arouse the breathing center in the brain stem. This in turn arouses the motor center for the diaphragm (in the spinal cord) and so brings on the movement of inspiration.

rate and depth of breathing are affected also by the amount of carbon dioxide in the blood circulating through the breathing center itself. So the simple three-neuron arc is very far from an adequate picture of the mechanism of breathing.

3. Branching paths. An adequate picture must show not only converging axons, but also branching axons by which any single neuron exerts an influence on several others. The nerve currents coming from one part are distributed to many parts. The numerous muscle fibers in a single muscle are

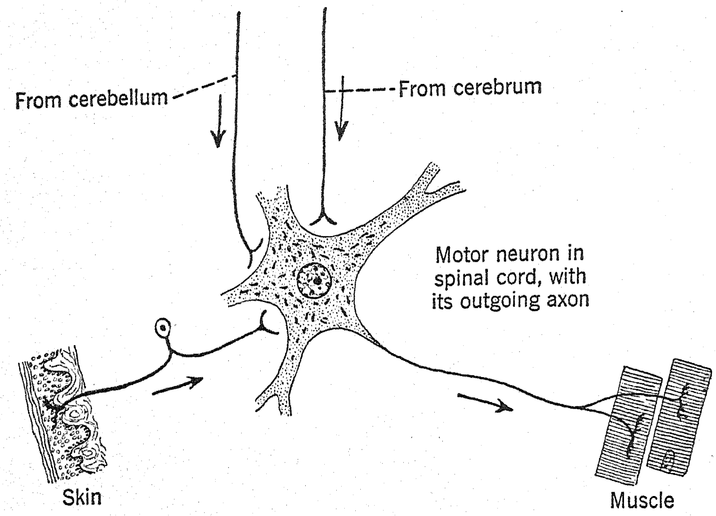

FIG. 40.—Converging nerve paths. The motor neuron in the cord which directly controls part of a muscle is stimulated by nerve currents from several sources. (Please disregard the disproportionate size of the motor neuron in this diagram.)

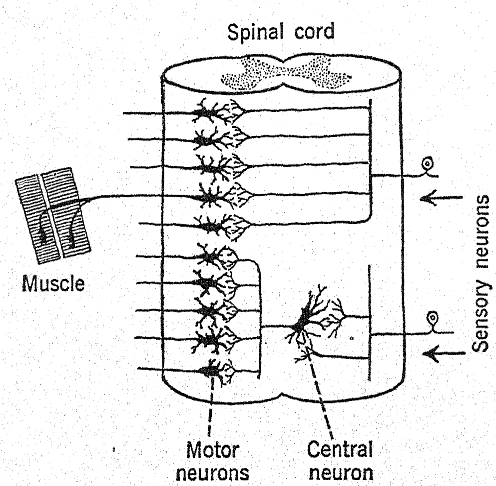

FIG. 41.—Branching of neurons. The result is the passing on of stimulation to many muscle fibers (of which only two are shown).

made to act together, and several muscles can be aroused at the same time in a co-ordinated movement (Fig. 41).

4. Continued activity. The reflex arc diagram may suggest a nerve center resting quietly till a stimulus arrives—whereas the typical condition of the nervous system as a whole is one of continued activity, activity in progress. The activity going on in the brain and cord is modified by the incoming nerve currents. We should think of the system as constantly active and constantly receiving stimuli which modify its activity.

THE BRAIN

There are many parts to the brain and many names for these parts, but the main parts of which we shall speak are these: the *brain stem* continuing the cord upward on an enlarged scale, and terminating in the *interbrain;* and two large outgrowths from the brain stem, the *cerebrum* and *cerebellum.* The brain stem and spinal cord, taken together, are the axis of the whole nervous system.

All the nerves of the arms and legs and most of the nerves of the trunk connect with the spinal cord, which contains the "lower centers" for these parts of the body. The nerves of the heart, lungs and stomach and the nerves of the head and face connect with the brain stem which contains the lower centers for these parts. The "higher centers" in the cerebrum and cerebellum are connected directly with these lower centers, and only by way of the lower centers do the higher centers have any connection with the muscles and sense organs, or with the environment. The lower centers co-ordinate the muscles into relatively simple teams; the higher centers co-ordinate the lower centers and so secure more elaborate teamwork from the muscles.

The cerebrum in man is much larger than all the rest of the nervous system put together; it fills most of the skull. Its right and left halves are called hemispheres. The right hemisphere is connected for the most part with the left side of the body and the left hemisphere with the right side of

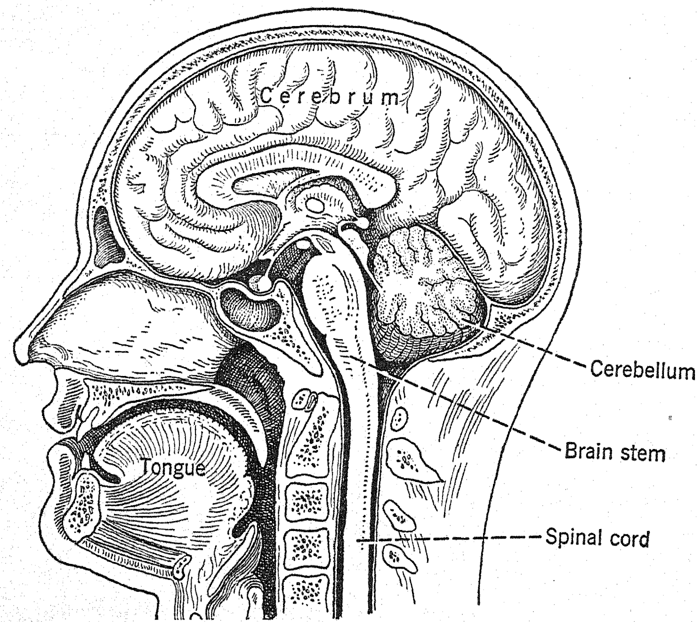

FIG. 42.—Location of the cord, brain stem, cerebrum and cerebellum.

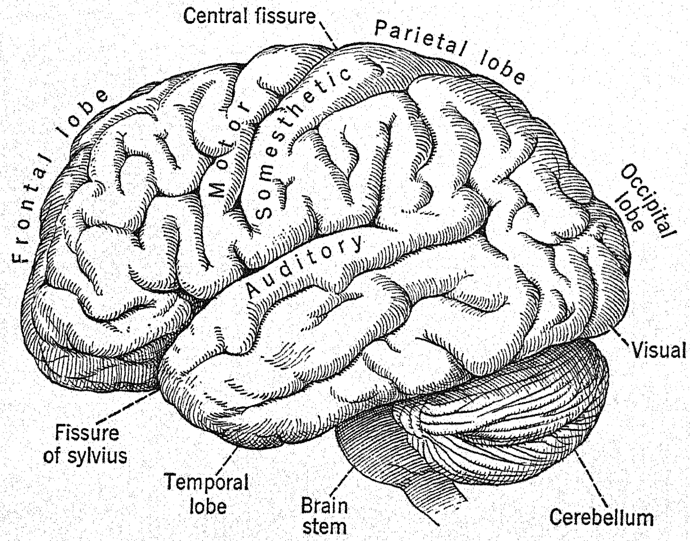

FIG. 43.—Side view of the left hemisphere of the cerebrum, showing the lobes and the motor and sensory areas. The visual area lies just around the corner from the point marked "Visual," as shown in Fig. 44. The olfactory area lies in a secluded position shown in Fig. 46.

the body. Of what service to the organism this crossed relation may be, no one has yet discovered.

The surface of the cerebrum as seen in Figs. 43 and 44 shows the well-known *convolutions* or *gyres* separated by *fissures* which extend down a little into the substance of the cerebrum but do not really divide it into separate parts.

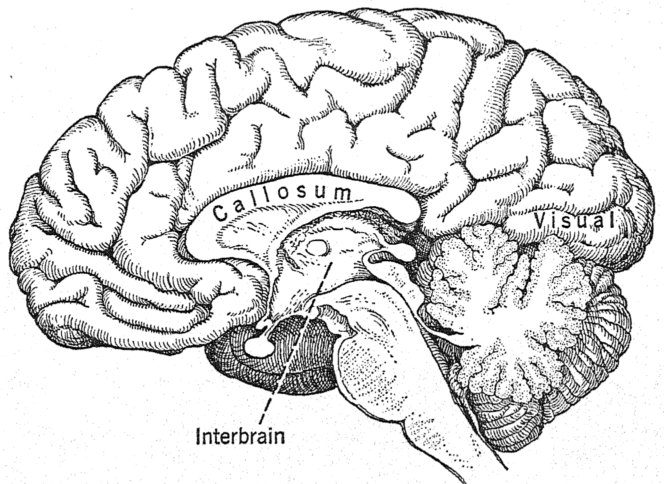

FIG. 44.—The middle surface of the right hemisphere, showing the visual area. The callosum is a great bundle of nerve fibers crossing from each hemisphere to the other and connecting the two into a single functional organ.

Even the major divisions of the cerebrum, called *lobes*, are not separate organs for they are continuous underneath. The *frontal lobe* inside the forehead extends back as far as the *central fissure*, behind which lies the *parietal lobe* and behind that the *occipital lobe*, lying at the rear of the brain. On the side of each hemisphere is the conspicuous *fissure of Sylvius* which separates the *temporal lobe* below from the frontal above.

The *motor area* lies in the frontal lobe just forward of the central fissure; the *somesthetic area*, that is the area for the cutaneous and muscle senses, lies just behind the central fissure in the parietal lobe. The *auditory area* lies in the upper margin of the temporal lobe. The *visual area* lies at the rear

of the brain in the occipital lobe as shown in Fig. 44. The justification for so naming these particular areas will be explained presently.

Gray matter and white matter. The external views of the brain give practically no idea at all of its mode of operation.

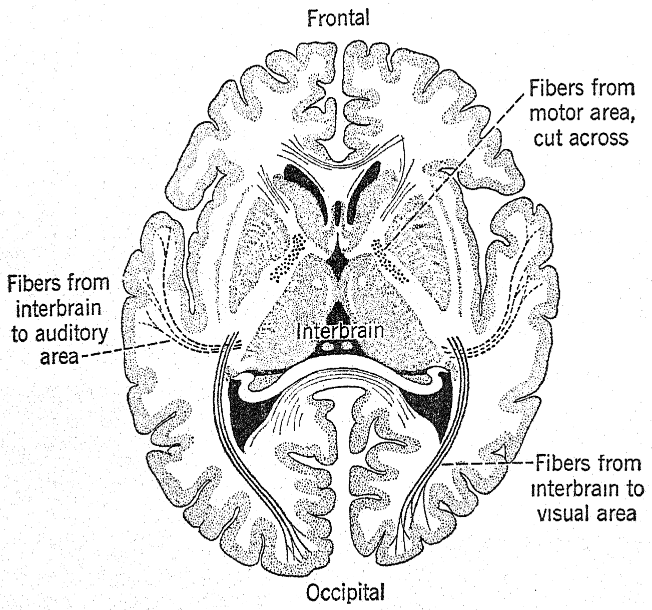

FIG. 45.—Horizontal section through the brain. White matter is shown in white, gray matter in gray, and fluid spaces in black.

It looks merely like a big mass and might be an overgrown gland of some sort. A section through the brain, either horizontal or transverse (Figs. 45 and 46), gives a very different impression. Even to the naked eye it shows a difference between white and gray matter. A large share of the gray matter lies on the surface and is called the *cortex* (bark) of the cerebrum. The cortex extends around the bottom of the fissures. There are also large interior masses of gray matter.

Viewed through the microscope, after suitable stains have been applied to the tissue, the white matter is seen to consist of nerve fibers crossing in various directions. The gray

matter is found to consist of nerve cells with their dendrites and of axons entering and terminating. The lower centers are masses of gray matter lying inside the spinal cord and brain stem, while the higher centers are largely in the cortex. About 50 percent of the brain and cord is white matter

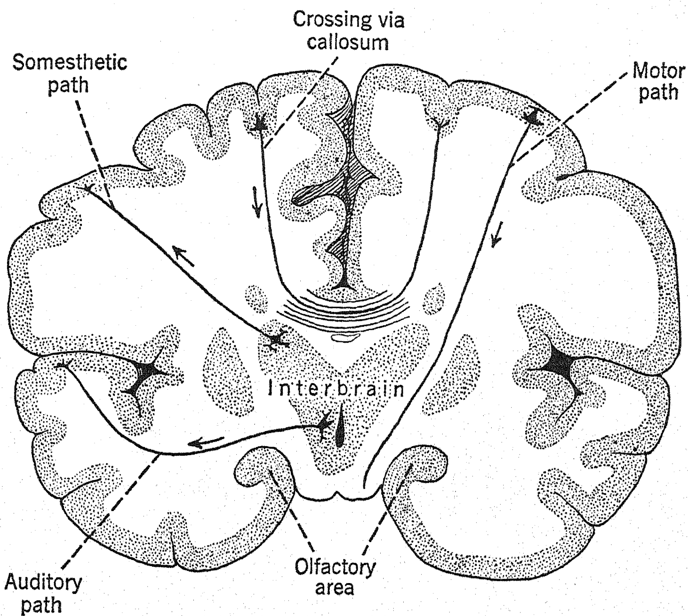

FIG. 46.—Transverse section through the brain. (The scale is larger than that of the previous figure.) Single fibers, each of which stands for many thousands, indicate some of the principal pathways: from the motor area down toward the lower centers, from the interbrain to the auditory and somesthetic areas of the cortex, and from one hemisphere to the other by way of the callosum.

and 50 percent gray. The white matter consists of nerve fibers connecting all parts of the gray matter, just as the external nerves consist of fibers linking the lower centers with the muscles and sense organs.

When highly magnified any mass of gray matter shows a very intricate internal structure of nerve cells, dendrites and axons. Some idea of this intricate structure can be obtained from Fig. 47. This particular bit of the cortex comes from the motor area and contains some giant pyramid cells,

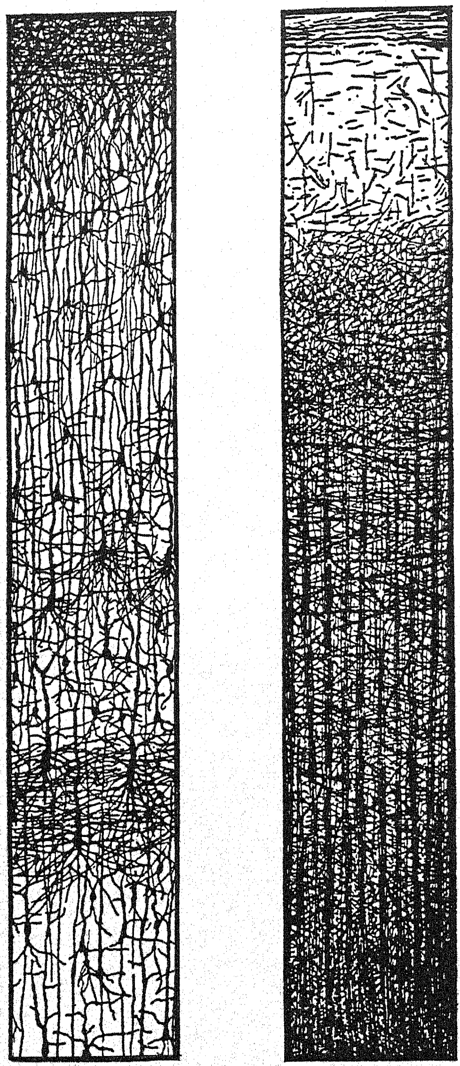

FIG. 47.—(Ramon y Cajal.) A small bit of the cortex magnified to show something of its internal structure. One view shows the nerve cells and dendrites with a few axons, while the other, being differently stained, brings out the axons and their branches. Imagine one view superposed on the other and you have some impression of the intricate interweaving of axons and dendrites in the cortex. Convergence of paths is carried to a maximum here.

one of which is shown separately in Fig. 48. Most of the cortex appears to be less well developed than the motor area. In fact all parts of the cortex differ in the fine detail of their inner structure.

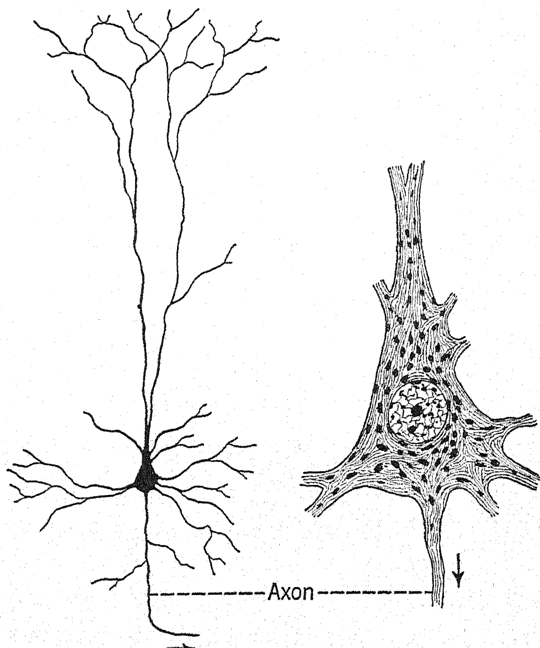

FIG. 48.—A giant pyramid neuron from the motor area. The second view shows its cell body still further magnified. The axon goes into the motor path shown in Figs. 46 and 49.

The total number of nerve cells in the cerebral cortex is estimated to be about 14,000,000,000. Many of these are small and apparently undeveloped as if they constituted a reserve stock not yet used in the individual's cerebral activities.

MOTOR AND SENSORY AREAS OF THE CORTEX

The question whether different parts of the brain differ in function has an interesting history. It has been a live scientific question ever since about 1800 when Gall pro-

pounded his famous theory of phrenology, a theory which had a vast popular vogue though it never received any scientific support. Gall himself was a scientific anatomist of good standing, but his method of study was rather primitive. When he noticed any individual with a peculiar shape of head, he tried to ascertain his mental peculiarities so as to relate different mental characteristics with different elevations in the external surface of the skull. These "bumps," he believed, showed where the brain was especially well developed. The intellectual faculties seemed to him to be located in the front part of the brain inside the forehead, the moral characteristics in the middle (as "veneration" at the very crown), and the animal propensities in the rear, sex desire for example in the cerebellum.

Gall's methods were too indirect and crude to yield any real evidence. A little later physiologists began to experiment by the method of "extirpation." Removing a part of an animal's brain, they noted the resulting changes in behavior. Flourens about 1825 showed that loss of the cerebellum disturbed the animal's posture and co-ordination of movement, and that injury to certain parts of the brain stem disturbed breathing, heart action and other internal functions. Loss of the cerebrum destroyed initiative, memory and understanding, but as far as he could determine the cerebrum functioned as a unit. In direct opposition to phrenology he set up the doctrine that the cerebrum acts as a whole. Flourens' view was accepted doctrine till about 1860, when evidence began to accumulate showing that it made a difference what part of the cerebrum was injured. The human evidence comes from cases of brain tumors, gunshot wounds and other injuries to parts of the brain. Definite losses of function have been noted during life and at autopsy localized brain injuries have been found. By the end of the nineteenth century there was general agreement on the location of the chief sensory areas and the motor area; and with further advance in technique and increase in case material these areas have been definitely established.

The methods used in studying brain localization are:

1. Method of *extirpation:* part of an animal's brain is destroyed, and the resulting losses of function are noted.

2. *Pathological* method: disturbed function is observed in a human subject, and autopsy sometimes reveals a more or less sharply localized brain injury.

3. *Stimulation:* weak electric currents are applied to an exposed region of the cortex to see what movements, if any, are elicited.

4. *Fiber tracing:* the connection of a certain part of the cortex with the eyes, of another with the ears, of another

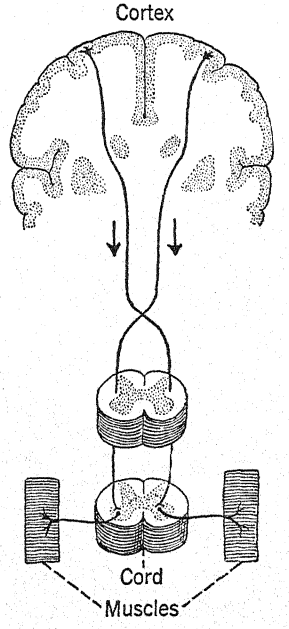

FIG. 49.–The principal motor path. Axons from the giant pyramids in the motor area pass down through the brain stem to some part of the spinal cord where they connect with the motor neurons and so with the muscles. Note the right-left crossing.

with the muscles, is established by tracing the fibers connecting the cortex with the lower centers.

The fiber-tracing method is especially convincing. When we find that the motor nerve fibers supplying the muscles

of the arm come from nerve cells in the spinal cord at the level of the shoulder, we are convinced that this part of the spinal cord is the lower motor center for the arm. When we find that the giant pyramids in a certain region of the cerebral cortex send their axons down to this shoulder level of the cord, connecting with the lower motor center for the arm, we cannot doubt that this particular cortical region is a higher motor center for the arm (Fig. 49).

It must not be supposed that this fiber tracing is an easy matter. The fibers are not tough cords that can be teased out over long distances. Bundles of nerve fibers course in every direction through the white matter and only very special methods make it possible to trace any one bundle for any considerable distance. One special method is that of "degeneration." An axon severed from its nerve cell loses its vitality and degenerates. It then stains differently from a normal axon and can be traced in a series of cross sections.

By the concordant results of these various methods the following functional areas have been established.

The motor area. If we ask which part of the immense surface of the hemispheres is most directly concerned with bodily movement, the fiber-tracing method points to a strip of cortex just in front of the central fissure, called the *precentral gyre*. Here are the *giant cells* which send axons down to the lower motor centers in the cord and brain stem. Weak electrical stimulation of this strip of cortex produces movements of different parts of the body according to the part of the area stimulated. Stimulation at the top of the brain (just at the crown, where Gall located the center for veneration) gives movements of the feet and legs. A little further down stimulation gives movements of the trunk, still further down movements of the arms. Near the bottom of this precentral gyre movements of the head, face and mouth are obtained. Injury to any part of this gyre produces paralysis, temporary or permanent, in some part of the body. For all these reasons this narrow strip of cortex deserves the name of motor area.

The complete motor region however includes something

more. It includes the cortex just in front of the motor area, which is often called the *premotor area*. This connects with the motor area and also has its own connections downward to the lower motor centers in the cord and brain stem. Stimulation of the premotor area gives movements which are more complex than those obtained from the motor area. The motor area seems to control single movements, the premotor area combinations of movements (7).

Even the motor and premotor centers taken together do not cover all the motor functions of the cortex. Eye and head movements can be obtained from the occipital lobe (as if in looking at a seen object), from the temporal lobe (as if in response to a sound) and from the frontal lobe (as if in spying out one's way).

Outgoing fibers lead from all parts of the cortex to the brain stem. A large share of them link the cerebrum through the brain stem with the *cerebellum*. This large organ has much to do with maintaining posture, equilibrium and muscular steadiness. The cerebrum and cerebellum work as a team, the cerebrum taking the initiative and providing the trained skill, as for example in kicking a football at the right time and in the right direction, while the cerebellum insures such an adjustment of posture as enables the player to kick and still maintain his equilibrium.

Sensory areas of the cortex. The cortex is not connected directly with any of the sense organs, but it is connected with certain lower centers for these organs which all lie rather close together in the *interbrain*. The interbrain lies underneath the cerebrum. It may be called the upper end of the brain stem (Figs. 44, 45, 46). Nerve fibers from the eye, the ear and the other sense organs lead to the interbrain, and relay fibers run from the interbrain to different parts of the cortex. The interbrain is an intermediate station or junction. It probably makes some essential contribution to sensory experience. Possibly it gives us the vaguer groundwork of experience, leaving to the cortex the more definite perception of objects, shapes, colors, tones and noises. This is speculative; what we certainly know is that each sense

organ communicates its messages to the cortex only by way of the interbrain. Each sense organ connects with a certain part of the interbrain, the localization there being quite minute.

The somesthetic area. The strip just behind the motor area, the *postcentral gyre,* is the chief cortical center for the

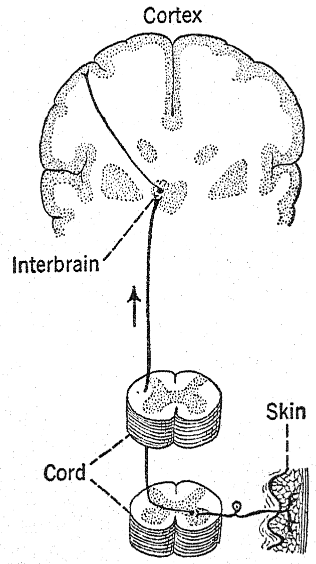

FIG. 50.—Sensory path from the skin of any part of the trunk or limbs. The path extends from the skin to the cord, from the cord to the interbrain, and thence to the somesthetic area of the cortex. See also Figs. 36, 43, 46.

body senses, that is, for the skin and muscle senses. The somesthetic area overlaps somewhat with the motor area in front and spreads out somewhat behind the postcentral gyre, making in all a rather broad area. Injuries here cause losses of sensation in the skin or limbs. The limbs are represented in the same order as in the motor area, with the leg at the top and the face at the bottom.

The auditory area. Sensory fibers from the ear run to the interbrain and from the interbrain relay fibers run to a small portion of the *temporal lobe* which is accordingly the auditory receiving center of the cortex. If this small region

is destroyed *in both hemispheres* the individual is probably rendered deaf, but such injuries very seldom occur.

The visual area. The sensory nerve fibers from the retina of the eye run back to a certain part of the interbrain, from which relay fibers run to a limited region of the *occipital lobe*. This limited region is the visual receiving center, the primary visual center of the cortex.

This connection of the eyes with the brain is interesting enough to warrant a more detailed description. From each eye the sensory fibers run back in the large optic nerve. The two optic nerves come together and appear to cross, but the fiber-tracing method shows that they do not all cross. The fibers from the inner half of each eye cross, while those from the outer half remain on the same side. So the fibers from the right halves of both retinas go to the right side of the interbrain, and relay fibers continue this path to the right hemisphere. The visual area of the right hemisphere gets the combined messages from the right halves of both retinas; similarly on the left side (*13*). (See Fig. 51, p. 276.)

Now consider how the eyes are placed in the head. In man they are directed forward and get almost (not quite) the same field of view. On account of the crossing of the rays of light inside the eyeball, the right side of the field of view is seen by the left half of each retina and therefore, according to the fiber connections, by the left hemisphere. Just as there is a crossed relation between the hemispheres and the right and left halves of the body, so there is a crossed relation between the hemispheres and the right and left halves of the field of view. The left hemisphere is concerned primarily with everything on the right, and the right hemisphere with everything on the left.

What kind of blindness, therefore, should result from destruction of the right visual area of the cortex? Not blindness of one eye, but blindness of the right half of each retina, i.e., blindness to the left half of the field of view. This type of blindness is called *hemianopsia* ("half blindness"). Smaller injuries to the primary visual area, such as are often produced by gunshot wounds in war, cause losses

of smaller parts of the field of view. The study of such injuries and the fiber-tracing method agree in showing that each part of the retina is connected with a different part of

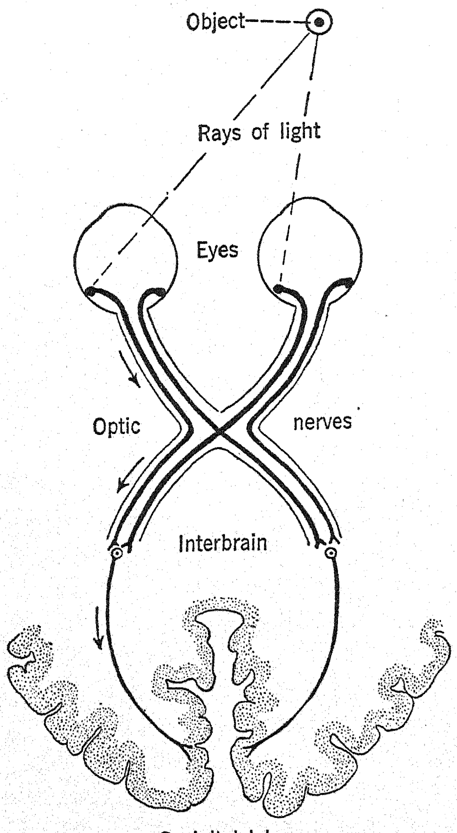

FIG. 51.—Path of light and nerve currents from a visible object to the visual area of the brain. The eyes are looking straight ahead. An object on the right affects the left half of each retina, the left side of the interbrain, and the left occipital lobe.

the visual area. The central part of the retina where vision is most distinct has a large share of the visual area devoted to it.

The primary visual area, then, consists of two parts, one part in each occipital lobe. It is rather curious that this division produces no discontinuity in the appearance of the

field of view—no line or gap between the right and left halves of the field. The integration of the visual field must be accomplished by the numerous fibers which connect the right and left visual areas through the great bridge of crossing fibers known as the callosum (Figs. 44, 45).

There is still another method of studying the visual area which gives striking and convincing results. When the skull is opened up and the occipital lobe is exposed to view for the removal of a tumor, a weak electric current can safely be applied to points on the cortex and the (unanesthetized) subject asked to report his experience. We might hastily assume that he would report pain, on the supposition that the brain must be very "sensitive." But no, stimulation of the visual area ought to give visual sensation. A leading student of these matters (*4*) reports the following results in one especially clear case: stimulation at the rear of the visual area caused the subject to see a bright light straight in front; at the upper part of the area it caused him to see a flickering something down below; at the lower part of the area it gave the same appearance in the upper part of the field of view. These localizations correspond to the results obtained by the other methods.

When the electric stimulus was applied outside the primary visual area but on neighboring parts of the occipital lobe, the subject reported more meaningful visual appearances; flames, stars, shiny balls, butterflies, various objects and even persons. Most of the occipital lobe is concerned in one way or another with vision. The primary visual area, receiving nerve currents from the retina, passes the stimulation along by short association fibers to the neighboring regions and the latter contribute to the understanding of what is seen. Injuries to the occipital lobe not involving the primary visual area do not produce blindness but do impair the subject's ability to recognize objects, to read, to distinguish colors, or to find his way by the sense of sight.

Recognizing a seen object is a *response* (p. 25). It is a response of some portion of the occipital lobe to stimuli coming (directly) from the primary visual area.

THE COMBINING OR ORGANIZING AREAS

The primary sensory areas are relatively small portions of the cortex and the motor region also is not large in comparison with the whole extent of the human cortex. These primary areas provide for the intake of sensory data and the

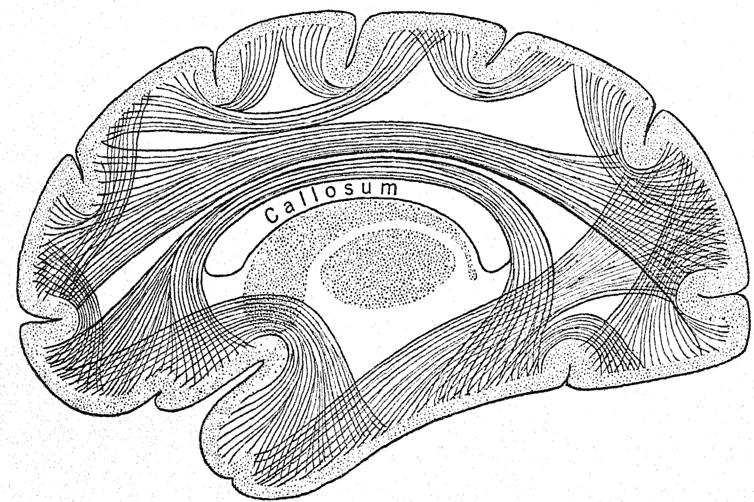

FIG. 52.—Sample axons connecting one part of the cortex with another. There are many millions of these "association fibers," connecting neighboring and distant parts of the same hemisphere or connecting one hemisphere with the other through the callosum.

outgo of motor response. The large remainder of the cortex is partially devoted to what is after all its principal job. We may call this job organizing. More specifically, the objective situation must be known. Objects must be recognized, what is going on in the environment must be understood. Goals must be adopted and means selected. Dealing with the objective environment is certainly the major function of the cortex.

We might expect to find the "faculties" of memory, reason, feeling and will located in different parts of the cortex, but there is no evidence for any such localization. The distribution of functions over the cortex follows an entirely different

principle, as we have just seen in the case of the occipital lobe. The cortex near the primary visual area is concerned with grasping the facts presented to the eye, and the cortex adjacent to the auditory area is concerned with the meaning of auditory data. In the neighborhood of the motor area the cortex seems to function in combining movements so as to reach certain goals and accomplish certain results. With the cortex adjacent to the primary areas thus accounted for, there still remain large areas whose function may be supposed, rather vaguely, to be that of associating, combining, synthesizing, integrating or organizing sensory data and motor responses. There is one large association area lying in the parietal, temporal and occipital lobes in between the several sensory areas, and there is another large association area in the frontal lobe forward of the motor and premotor areas. Some evidence regarding the function of these areas has been obtained in cases of brain injury in man. The results of such injuries are classed under several heads (*12*).

Aphasia, loss or impairment of speech, occurs in a variety of forms and results from different brain injuries. The main speech center seems to lie in the temporal and parietal lobes not far from the auditory area. This is not strange since speech is primarily an auditory affair. The child understands words before he can speak them, and when he learns to speak he is trying not so much to make certain movements of his speech organs as he is to produce certain sounds. Because of injury in the neighborhood of the auditory area, an individual may be unable to understand spoken speech or to find the right words to express his own meaning even though he speaks fluently enough. One old gentleman mystified his friends by saying that he "must go and have his umbrella washed," until it was discovered that he wanted his hair cut!

Besides this sensory type of aphasia there is a motor type in which the great difficulty is to get the words out. Some subjects can speak only one or two words of frequent usage (as "yes" and "no" and swear words), while other subjects can pronounce separate words but cannot put them together into sentences. In this class of cases the injury is apt to be

found in the premotor area. The lower part of the premotor area has long been regarded as the motor speech center though of late years some skepticism has arisen regarding this area, pure cases of motor aphasia being very rare. Usually the brain injury is rather diffuse and the individual's intellectual processes are disturbed in many respects.

One striking fact on which there is general agreement concerns the dominance of the left hemisphere in right-handed persons. Aphasia results from injuries of the left hemisphere in such persons. The facts in regard to left-handed persons are not so clear.

Apraxia, loss of ability to "do," is akin to aphasia. Give the individual a box of matches and a cigar, and he may be unable to make the right combination, though capable of executing all the necessary single movements. The brain injury varies in location but is usually not far from the motor area.

Agnosia, loss of ability to know or perceive. Visual agnosia consists in inability to recognize seen objects, to read, to recognize shapes and colors, etc. It is caused by injuries in the occipital lobe. In auditory agnosia sounds cannot be recognized or music cannot be followed and appreciated as before. The injury here is in the neighborhood of the auditory area. When the injury is close behind the somesthetic area the subject cannot recognize objects placed in his hands, or judge weights by lifting them, etc. In any form of agnosia the subject still sees, hears or feels but does not utilize the sensory data as signs of definite objective facts.

Language as we said a moment ago is primarily auditory and secondarily motor. Obviously language is not the mere production of certain sounds. It is a means of communication, and the sounds carry meaning. Language is symbolic and the trouble in brain injuries which give aphasia may be that the subject has lost his ability to use symbols. Agnosia similarly can be regarded as an inability to get the meaning of signs and symbols. Apraxia can be thought of as inability to connect one's meanings and intentions with the concrete acts which are necessary to carry out these intentions. Sym-

bols and skilled movements are tools in intelligent behavior. These tools apparently depend on definite parts of the cortex but their use in intelligent behavior very likely depends on the cortex as a whole.

The frontal lobes. When Gall in his system of phrenology located the intellect in the forehead, he was following our everyday notions. We think of the high-browed individual as intellectual, and we point to the low-browed animals in confirmation of our view. The frontal lobes are in fact much larger in the human than in any animal brain. Let us ask ourselves, however, whether the human being is characterized exclusively by intellectual superiority. Is it not equally remarkable how he manages his activity, seeking distant goals and planning his actions? The frontal lobes might be concerned with management rather than with knowledge. The whole frontal lobe might be an adjunct to the motor area, a supermotor area organizing action into large units.

Frontal lobe injuries in man sometimes produce remarkably little change in behavior or intellectual processes. One sometimes wonders whether this part of the brain has any function at all beyond filling up the expansive forehead. The changes observed, however, do lie rather in the realm of management and character than in that of intellect and knowledge.

Behavior after removal of the frontal lobes (*2*). A successful broker on the New York Stock Exchange when about 40 years of age began to suffer from severe headaches, absent-mindedness and failures of memory which culminated in a prolonged loss of consciousness. X-ray examination revealed a tumor involving both frontal lobes. An operation was performed which at first seems inconceivably daring but which has been successfully performed several times in the last few decades: the skull was opened and both frontal lobes were removed as far back as the premotor area. Care was taken not to disturb the motor and premotor areas including the motor speech center.

The patient made a good general recovery from the operation and was promptly relieved of his headaches and other

intolerable symptoms. He showed no inclination to go back to work and in some respects his behavior showed that he was not his old self. He seemed to have lost consideration for the feelings of his friends and to be incapable of sustained and serious effort. In the hope of re-educating him he was kept under careful medical observation for over a year, in his home and elsewhere. His behavior showed some improvement but not so much as to enable him to resume active business. Our interest in the case is to discover the losses, intellectual or behavioral, caused by removal of the prefrontal portion of the brain.

He had lost his zest for business. Yet he was far from somnolent or inactive. He was overactive in trifling ways, unwilling to sit still, preferring to walk or dance around the room and to sing, whistle or shout on all occasions.

He had lost his customary restraint and control of such natural impulses as those of sex and self-aggrandizement. He became very free in sex talk and playful sex behavior, but serious marital behavior disappeared nor did he make any serious advances to other women. He gratified his desire for self-aggrandizement by boasting of his prowess in athletics, in dancing, in business, and by claiming the ability to do anything that was mentioned. He made threats freely but did not carry them out.

In the psychologist's examining room he was overactive, facetious and distractible, and needed constant prodding to complete the tests. When allowance was made for these disturbing factors, his intelligence appeared to be normal. He was especially poor in sentence completion, picture completion, and similar tests which demand putting things together to make a meaningful whole. He seemed to have more intellectual ability than he was able to marshal for the purpose in hand.

What, essentially, had the patient lost? No faculty such as observation, attention, memory or reasoning was absent after the operation, though none of them, perhaps, was displayed to the full extent of the subject's previous ability. The investigator concluded that the deficiency lay in getting

the various mental processes to work together. What was impaired was synthesizing or combining ability. The subject's free expression of emotion in the postoperative state was due not to an exaggeration of the emotions but to a lack of restraint, and the lack of restraint was a result of loss of synthesizing ability. Without this ability the individual cannot plan his actions or restrain impulses that are likely to lead to undesirable consequences. From lack of synthesizing ability he is impulsive and distractible, and does not steer his behavior consistently toward a distant goal. In other cases of frontal lobe injury the symptoms vary somewhat but can be brought under the formula stated, though different students of the matter formulate their interpretations in various ways.

Two kinds of synthesis or combination. The brain must perform two kinds of synthesis or combination (see p. 38). One we may call incoming and the other outgoing. When you recognize a person, the stimulus is very complex, the picture on your retina has many parts. In seeing him as a person you combine the many into one, you make a unitary response to a plurality of stimuli. When you see a motion picture what you get on the retina is a rapid sequence of different stimuli, but what you "see" is a continuous unitary movement or action. When you hear a piece of music your ear receives a succession of tones but you hear a tune, having the character of a unit. All these are cases of incoming synthesis, with plurality in the stimulus and unity in the response.

Outgoing synthesis is illustrated in every co-ordinated movement, since several muscles are brought into play, either in response to a single stimulus as in reflex action, or in response to a unitary intention. The intention to catch a ball brings both your hands simultaneously into position. The intention to open a door puts you through a sequence of movements leading toward the desired result. In outgoing synthesis the unitary antecedent produces a multiple consequent; the one gives rise to the many.

Obviously the two kinds of synthesis call for different

neural mechanisms. A collecting mechanism is required for the incoming synthesis, a distributing mechanism for the outgoing type. The rudiments of such mechanisms have already been described (pages 259, 262). When several nerve fibers converge upon a single cell as they do in every nerve center, we have a collecting mechanism. When a single axon branches and stimulates several neurons, we have a distributing mechanism.

Of the two great association areas of the brain the posterior one, lying between the various sensory areas, may probably carry out synthesis of the collective type. It would thus be concerned in knowing and understanding. The frontal association area may be concerned with the distributive type of combination. It would thus be concerned with planning, organizing and managing action. This allocation of the two types of synthesis to the two great association areas is a fascinating idea but not demonstrated by any means.

GENERAL FUNCTIONS OF THE WHOLE CORTEX

Seeing and hearing are known to be specific functions of small areas of the brain. The two types of synthesis are perhaps functions of certain large areas. There may also be general functions of the entire cortex. One general function is probably that of learning and remembering. Though there may be some of this in the lower centers the cerebral cortex is the part of the nervous system principally concerned in learning. The study of animal learning has been very active since about 1900 and has made important contributions to general psychology some of which will be noted in the next chapter. It has also made some important contributions to our knowledge of the cortex. The method of experimentation combines animal training and localized brain injury (*6*). An animal is trained to perform a certain act, then a part of the brain is removed and the animal tested to see if he can still perform the learned act.

The method seems a good one but its results are surprising.

A performance such as following a path to a goal or as manipulating a door latch, learned by a monkey before removal of the frontal lobe, is *lost* as the result of that operation but can be *relearned* with further training. The only possible conclusion seems to be that different parts of the cortex can function in learning the same performance.

Loss of learning ability dependent on amount of cortex removed. A similar result is obtained when a white rat has learned to find his way quickly through a "maze," a complicated set of paths and blind alleys. Injury to almost any part of the cortex impairs or obliterates this learned performance, which can however be relearned. Loss of almost any part of the cortex impairs the rat's learning ability, and the larger the amount removed the greater is the impairment. The impairment is seen in the following table from the increase in errors committed before the maze is mastered.

MAZE LEARNING BY RATS AFTER OPERATION (*10*)

Amount of Cortex Removed	*Number of Errors Committed*
none	33
1-9%	53
10-19	143
20-29	293
30-39	449
40-49	964
50-59	950

These results show that a learned act is not necessarily controlled by one particular cortical center. We cannot hope to map the cortex into small, distinct centers, each presiding over a specific mental or motor performance.

These results suggest that it is proper in a way to go back to Flourens and say that the cerebrum functions "as a whole." But the words must not be taken in a literal sense as if every cell and fiber of the brain were simultaneously active all the time. For then there could be only one brain

activity, instead of the thousands of varied brain activities which are vouched for by the varieties of behavior. The best conclusion is that *the brain acts in wide-spreading patterns,* patterns that involve many cortical areas and their connecting association fibers. The pattern of brain activity must *shift* from moment to moment; a bit of behavior that takes only a minute may bring most of the brain into action during the minute. Loss of any large amount of cortex will disturb the interaction of parts and break up the usual pattern.

Situation set as a general function of the cortex. Rats with large losses of cortex lack energy in exploring a strange place and in attacking a problem such as that of securing food from a closed box (*9*). They lack persistence and variety of attack. They wander about vaguely and appear only half alive to the situation. It appears that the loss of any considerable portion of the cortex impairs the rat's ability to get up a good situation-and-goal set. Such an adjustment is probably an activity of the brain as a whole rather than of any single center. The frontal lobes may be concerned with directing activity toward a goal, while the posterior half of the cortex is concerned with grasping the situation. Since, however, situation-and-goal set is one adjustment and not two, the frontal and posterior parts must work together whenever the individual is dealing effectively with the environment.

MATURATION AND USE IN THE DEVELOPMENT OF THE BRAIN

There is abundant evidence of maturation. The first rudiment of the nervous system appears when the embryo is about two weeks old (Fig. 53). A longitudinal groove appears along the embryo's back and soon closes into the form of a tube. At the head end the tube develops rapidly, and by the early age of four weeks of embryonic life the main parts of the brain are distinguishable (Fig. 54). In these early stages, the cells composing the rudimentary brain and spinal

cord are not yet neurons, but they later differentiate into neurons and send out axon and dendrites. The motor neurons and nerves develop in advance of the sensory. The brain is very forward in its development. In the early stages it is a large fraction of the whole organism, at birth about $\frac{1}{10}$, at maturity about $\frac{1}{50}$. The lower centers begin to function before birth, but the cortex is apparently not in a

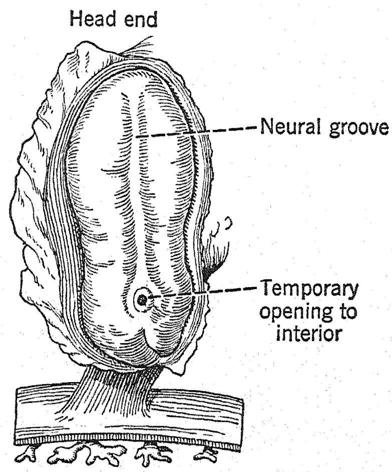

FIG. 53.—(Von Spee.) Dorsal view of a two-weeks human embryo, magnified 20 diameters.

functional condition till some weeks after birth. Obviously the differentiation of the various parts of the nervous system takes place before they begin to function, and obviously the neurons cannot function till they have sent out their axons and dendrites and established connections with each other and with the receptors and effectors. In short the main structure of the nervous system must be credited to maturation.

Evidence for growth of the nervous system resulting from its own activity is necessarily hard to obtain. We cannot expect the head to swell visibly as the result of brain activity. The most we could expect would be that the microscopic structure of the cortex would become more intricate. Though no new nerve cells are formed after birth, growth

of the cells and their branches continues rapidly in early childhood and more slowly on into adult life. This growth need not be entirely due to activity but activity is probably a stimulating influence. In the primary visual area, which is

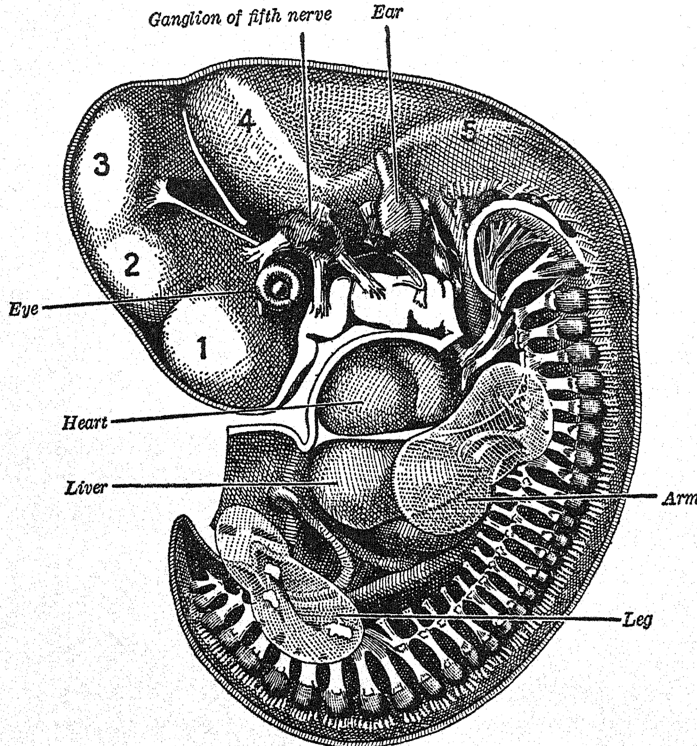

FIG. 54.—(Streeter.) Human embryo of four weeks, magnified about 10 diameters. The numbered parts are the rudiments of the main divisions of the brain, 1 being the cerebrum, 2 the interbrain, etc. The spinal cord shows in gray and is continuous with 5, the rear portion of the brain stem. An arm and a leg appear as transparent buds.

certainly active enough in childhood, the nerve cells increase in size up to the age of eight years and apparently to some extent even later (*4*). In individuals who become blind at an early age, this development in the visual area is much less marked (*3, 8*). We conclude that use does develop the internal structure of the visual cortex. In fact, we can scarcely escape the belief that all activity that leaves a per-

manent effect on the individual must change his structure somewhere, and in many cases the cortex is the only likely place. When experience leaves its mark on the individual, the mark must usually lie in the gray matter of the brain.

Summary of the chapter. The main purpose of the chapter is to convey some rudimentary acquaintance with the nervous system including the brain, spinal cord and nerves. The mechanism of reflex action provides for selection and combination which are operative in a larger way in brain activity. As to the debated question regarding the localization of functions in the brain, the evidence is clear for localization of the senses and of muscular movement. There is some indication that the frontal lobes are concerned with management of planned activity, and that the rear half of the brain is more concerned with knowing and understanding things. Learning seems to be an unlocalized function, and adjustment of the organism for the total situation and for a goal is probably a function of the entire cerebrum.

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Chapter IX

Learning

NO TOPIC in the whole broad field of psychology is more fundamental than the one we are to consider in the two chapters now before us. Whatever other topic we take up, whether intelligence, personality, emotion, sense perception, or thinking, we always have to refer to learning as a decisive factor. In studying the development of personality, we saw the importance of social influences, but we also noticed that the individual is not passively molded by society as if he were a mass of putty. He is plastic in a very different way. He responds to the environment and is developed by his own activity. He picks up the group culture by a process of learning, and he learns his own special role as well. While the social sciences can simply assume that the individual learns, and let it go at that, one distinctive task of psychology is to trace out the process of learning. Psychology must discover *what* is learned, *when* or in what conditions it is most easily learned, and, if possible, *how* it is learned.

Learned and unlearned behavior. When the newborn infant starts to breathe, he is performing an act that he has had no chance to learn. The lungs and the muscles and nerves necessary for respiration have been developed so far by maturation (pp. 209, 217). In the course of time the child does learn to breathe in special ways, as in holding his breath at will or in blowing out a candle. These modifications of breathing are based on the original unlearned act. Any act, even though provided in its primitive form by maturation, is almost sure to be modified in some way by exercise.

Definition. We need a broad definition of learning. It should include more than school learning and other cases of learning by study and effort. A song that you have heard several times without ever intending to learn it has been learned, nevertheless, if you find yourself humming it. Even if it simply sounds familiar, it has been learned to some extent. All knowledge, however acquired, all skill resulting from motor activity, all habits, all acquaintance with people and things, all attitudes built up in dealing with people and things, have been learned in the broad sense of the term.

Whenever any act shows the effect of previous activity, aside from such temporary effects as fatigue, it shows the effect of learning. Learning, then, is any activity that produces a relatively permanent effect on later activity.

Learning seems not to be limited to any one sort of activity. We learn to write by writing, we learn the plot of a story by reading the story, we learn a person's face by seeing him. Any activity can be called learning so far as it develops the individual (in any respect, good or bad) and makes his later behavior and experience different from what they would otherwise have been.

ANIMAL LEARNING

Nowhere in psychology has the experimental method been more fruitful than in the study of learning. The first experiments, about 1880, were concerned with human memory. A few years later work started on the learning of skilled motor performances, followed at the turn of the century by the pioneer experiments on animal learning. These leads have all proved excellent and are still being followed energetically. None of them have been more interesting to psychologists than the work on animals.

Why should psychologists be so much interested in animal learning? Of course they would like to know whether animals are capable of learning, but a few experiments were sufficient to prove that the higher animals learn a great deal and that some power of learning is present far down the

animal scale. The real interest arises from the belief that animal learning is a simpler process than human. The human adult uses a lot of verbal aids that are beyond the scope of the animal, and in other ways utilizes his superior intellect. Probably the animal shows us the rudiments of learning more clearly than man, just as the architecture of a cottage helps in understanding the structure of a cathedral.

If animals are to be made useful to psychology, care must be taken to observe them as objectively as possible, without reading human characteristics into their simpler behavior. If we carelessly assume that the animal is thinking and feeling as we should in the same situation, we miss our chance of getting a glimpse of the more primitive, subhuman way of solving a problem. We must be on our guard against anthropomorphism. This principle was laid down by one of the founders of animal psychology and is named, in his honor, *Lloyd Morgan's canon.* As he put it, "In no case may we interpret an action as the outcome of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale" (*21*).

If we see a dog open a gate by raising the latch with his muzzle, we should not assume that he has reasoned out the solution of this problem. We should first observe a dog's behavior in the process of reaching a solution, as was done by Lloyd Morgan with his fox terrier. When the dog was placed one day in a yard enclosed by a picket fence, he showed eagerness to get out into the adjoining street. He thrust his nose out between the pickets in one space after another. The gate latch was in one of these spaces and when the dog stuck his head there he happened to raise the latch. The gate swung open and the dog went out into the street. On later days the dog still tried one space after another but narrowed down his field of operations bit by bit till finally he always went directly to the right space and lifted the latch with a definite head movement.

Trial and error. This simple experiment will repay some discussion. Nothing in the dog's behavior suggests reason-

ing. He solved the problem the first day by trying the obvious leads till one proved successful. This kind of behavior is called trial and error. The minimum essentials of trial and error behavior are:

1. A "set" to reach a certain goal, as the dog was bent on getting out into the street.

2. Inability to see any clear way to the goal.

3. Exploring the situation.

4. Seeing or somehow finding leads, possible ways to reach the goal.

5. Trying these leads.

6. Backing off when blocked in one lead, and trying another.

7. Finally finding a good lead and reaching the goal.

It is correct to say that the dog "solved the problem by trial and error." That was the way he attacked the problem, and he succeeded in time. It was not a very efficient line of attack, not a very intelligent process of solution, but it was probably the only line a lively, impulsive fox terrier could take. Even a man resorts to trial and error when he cannot see his way through.

Shall we also say that the dog *learned* by trial and error? Preferably not, for we should not be telling how he learned. He learned in the course of trial and error, but *what part* of that complex process enabled him to cut down the amount of trial and error, day by day, and finally to master the trick? His behavior included a lot of motor activity; less obviously but just as surely he was using his senses. He explored, found leads, and found most of them bad and one good. Trial and error behavior comprises observation and bodily movement, and the question is whether the animal learns by moving or by observing.

The alternatives may be clearer if we ask *what* the animal learns. Does he learn what movement to make, or what lead to follow? At first he makes a variety of movements and tries many leads, but in the process of learning he eliminates most of them. Does he keep the right movement,

or the right lead? The experiments now to be described may throw some light on this important question.

The cat in the puzzle-box. Place a hungry young cat in a small cage, with a bit of fish lying just outside, and you

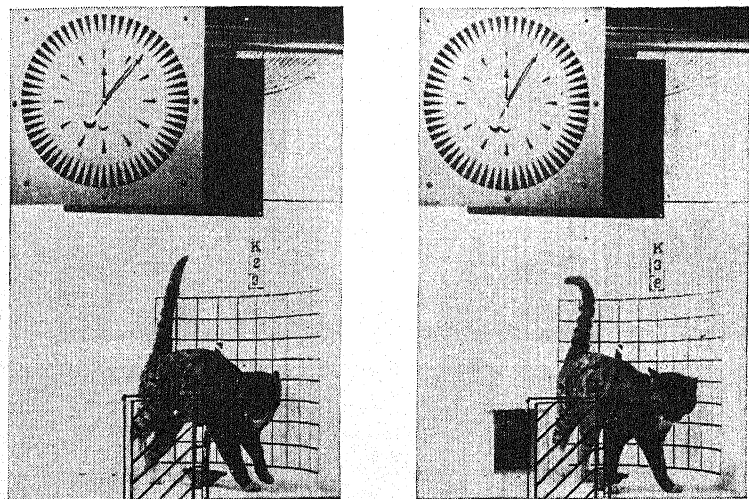

Fig. 55.—(Courtesy of Horton & Guthrie, *9*.) Cat opening the door of a puzzle-box by pushing a pole with her side. The cat entered the box or cage by the small door at the back and advanced toward the wire door in front, meanwhile pushing the upright pole with her left side. Any push on this pole opened the front door. The two views show the same cat in two trials, and the clock gives the time up to the moment of pushing the pole; it reads 6 seconds for trial 23, and 5 seconds for trial 38. This particular animal always pushed the pole with her left side. Other animals used a paw or the head, many of them in this situation adopting a stereotyped procedure. In other puzzle-boxes each animal's procedure is apt to vary from trial to trial.

usually get plenty of action. The cat extends his paw between the bars of the cage but cannot reach the fish; he pushes his nose between the bars but cannot get through; he bites the bars, claws at anything small, shakes anything loose, and is likely to try every part of the cage, though mostly the parts near the fish. Sooner or later he turns the button which is holding the door shut; the door opens and the cat goes out to his reward. The experimenter, having recorded the time occupied in this first trial, replaces the still hungry cat in the cage with another bit of fish outside. Same

business, with somewhat quicker escape. In further trials the useless movements are gradually eliminated, till finally, on being placed in the cage, the cat promptly turns the button and gets out within a couple of seconds. Perhaps 10-20 trials, distributed over several days, have been required to master the trick.

Older cats, or placid cats, or cats that for some reason are not so eager, go through less of this motor activity and yet may learn the trick in fewer trials than the excited ones—a fact which suggests that the use of the senses rather than vigorous motor activity is the important factor in learning. Another relevant fact is that the cats, after once getting out, concentrate their activity in the region of the door; they learn the "lay of the land." In one type of puzzle-box a loop of string or wire, hanging in the cage, will release the door if given a pull. The cats soon concentrate their activity upon this loop. If the experimenter moves the loop to another part of the cage, the behavior of the cats is interesting in two ways. They go first to the place where the loop has been and claw in the air there as if expecting to find the loop—thus showing that they have learned the *place*—and later when they find the loop in its new position they pull it as they have learned to do in its former position, showing that they have learned the *thing*. They are dealing with things rather than going through a gymnastic exercise. But, one may ask, have they not learned simply to make certain movements at sight of certain things? If that were a fair statement, they should always, after learning a trick, execute it with the same movement. As a matter of fact, the cat that has learned to pull a loop sometimes uses her claws and sometimes her teeth to secure the same result. Sometimes the movement becomes stereotyped but usually not (*1, 11, 28*).

On the whole, observation or the use of the senses seems closer than motor activity to the heart of the learning process. Motor activity is of course necessary in investigating the various leads, but the important factor is *seeing the result* of a movement rather than merely executing the movement. If we ask what the cat learns in the puzzle-box, the best answer

is that she gets acquainted with the box, the location of the door and other important objects, and the use of these things as means of escape.

"Insight" experiments on monkeys and chimpanzees. Monkeys are cleverer than cats and dogs and can learn more intricate tricks. Having more power of manipulation they show even more clearly than cats and dogs that they are dealing with things and that their learning consists in becoming acquainted with things. The anthropoid apes, especially the chimpanzee, are "brainier" than the smaller monkeys—at least so far as brain size goes—and probably approach most nearly to human ability.

An objection sometimes raised to the puzzle-box and similar experiments is that they do not allow the animal a fair chance to show his full power of observation, because the bolts, buttons and other operating devices are concealed, unobtrusive or meaningless to the animal. If the situation were openly presented, it is said, the animal's behavior would show clearly that he is learning by observation. He might not see through the situation at the first glance, but at some time he would suddenly shift from helplessness to complete grasp of the problem, and at that moment the essential learning would occur. This would be learning by "insight."

A chimpanzee, having first learned to use a stick to pull in a banana on the floor outside his cage, was given two sticks of bamboo, one small enough to fit into the open end of the other, and the banana was placed too far away to be reached with either stick alone. Would the animal have intelligence enough to make and use a *jointed stick?* After an hour of unsuccessful reaching in various ways with the single sticks, the chimpanzee seemed to give up and went back to the rear of the cage. While there he began playing with the two sticks and by chance, as it seemed, got them end to end and pushed the smaller one a short distance into the larger. Up he jumped and ran to the front of the cage, and started pulling in the banana with his jointed stick. The loosely joined pieces fell apart, but he promptly put them together again and secured the banana. Without stopping

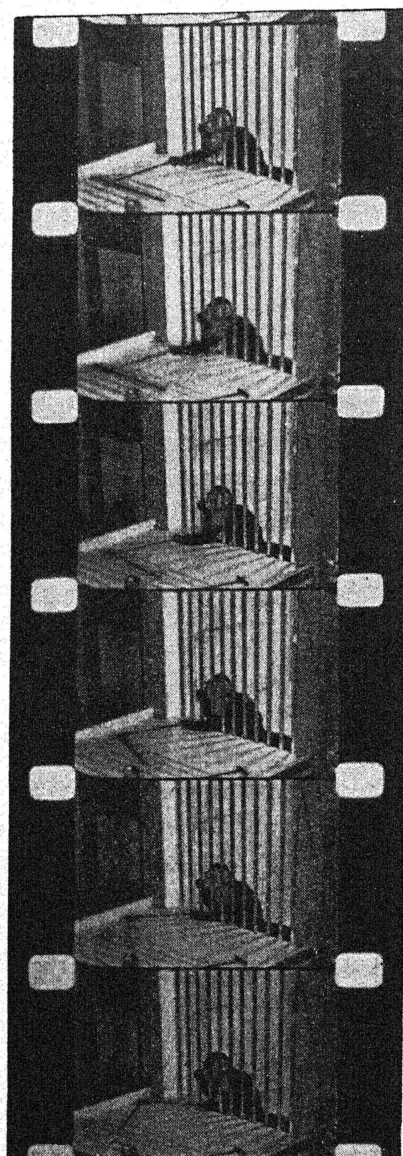

Fig. 56.—(Courtesy of C. J. Warden & G. M. Gilbert.) Monkey working at a multiple stick problem. To reach the incentive the longest stick is needed, and a series of shorter sticks must be pulled in, one after the other, in order to secure the longest stick.

to eat, he pulled in everything else within the reach of his new tool. Next day, on being retested, he began with a few useless movements but in just a few seconds reconstructed his jointed stick and used it as before.[1] The evidence for insight lies in the sudden transition from blind behavior to definite use of the jointed stick, in the almost complete absence of trial and error on the second day, and in the animal's interest in the tool itself (*15*).

Shall we regard this dramatic incident as the typical case of learning and conclude that all learning is learning by insight? In other experiments even chimpanzees—yes, even men—show a melancholy lack of understanding of some mechanical device and still acquire a practical mastery of it. The word *insight* is too strong. We humans, in this modern age, learn to manage automobiles and radios without having more than the vaguest insight into their mechanism. No one has complete insight into any concrete thing. If we use the word insight we should understand it to include even the most superficial observation of anything that can be used to help solve a problem. The child who "sees" that pushing the wall switch turns on the ceiling light must be allowed to have "insight" though he has not the faintest idea of the wiring or of the nature of an electric circuit.

Insight is sometimes *foresight* and sometimes *hindsight.* When the chimpanzee, having made his jointed stick, ran to the front of the cage and reached for the banana, he showed foresight. At that moment he foresaw success. He could see through to the goal. The dog behind the gate in our first experiment could not see any sure way to reach the goal. All he could see was leads, possible ways to the goal. When he tried a lead and was blocked he may have had some hindsight, i.e., he may have noticed that this was a false lead; and when he tried the lead that worked, he may have noticed that this was a good lead. Foresight is seeing the way to the goal before taking it, and hindsight is seeing that a lead is good after trying it. When the whole situation is presented

[1] This experiment has been repeated with similar results on young children (*2*).

openly, there is a chance for foresight, but when the essential characteristics of the situation are concealed, the most we can expect is some measure of hindsight.

Because insight usually implies some penetration into the true nature of things, we had better avoid the word and speak simply of learning by observation. Even this word is rather too strong, as it suggests deliberate effort to observe. All we mean is that the animal, through the use of his senses, gets acquainted with the usable characteristics of the situation. In the case of foresight the animal, inspecting the field of operations, perceives a way to the goal, as he can when the way is direct and unobstructed. Very often, however, the usable characteristics of a situation cannot be discerned by mere inspection, and then trial and error are necessary and observation consists largely in hindsight.

It would be a great mistake to limit our study of learning to cases where foresight occurs, for man as well as animals resorts to trial and error when the problem is blind. And it would be a mistake to limit our study to the animals that most resemble man if we wish to discover the minimum essentials of the learning process. Going some distance down the animal scale, psychologists have chosen the albino rat as an animal well suited for experiments on learning. The white rat is bred in the laboratory and his heredity, age and past experience up to the time of an experiment are known. (These important variables are controlled also in the modern primate laboratories, *36*.) The white rat is fairly tame and well adjusted to laboratory conditions. He makes a good subject and the only trouble is that he is too good a learner to reveal the process in its very simplest form.

The white rat in the maze. The human subject working on a pencil maze such as that on p. 107 is able to look ahead and use foresight. The rat in an enclosed maze (Figs. 57, 58) cannot possibly see his way through to the food box. When first placed in the maze the rat may hesitate timidly at the entrance but soon he begins to *explore*. He goes back and forth sniffing everywhere, enters all the passages, and in the course of these wanderings comes to the food box. Re-

placed at the starting point, he shows *more haste* and dallies less in the blind alleys. In successive trials he goes less deeply into the blind alleys, and finally passes the entrance to an

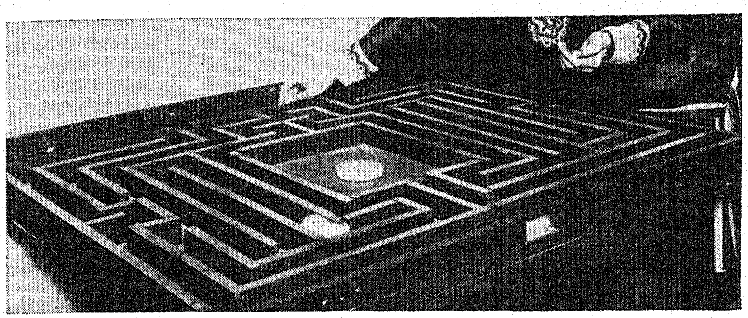

FIG. 57.—(Courtesy of C. J. Warden.) The white rat exploring a maze. This is the old Hampton Court design of maze, mostly replaced for animal experiments by more standardized forms. The wire-mesh cover has been removed for photographic purposes. The rat is seen in a blind alley. The experimenter is taking the time with a stopwatch.

alley without so much as turning his head. Eventually he passes all the blind alleys and runs swiftly from the entrance to the food box.

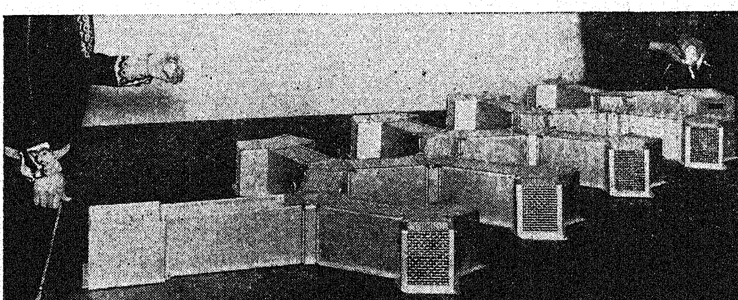

FIG. 58.—(Courtesy of C. J. Warden.) A modern type of maze. The rat is being placed at the starting point by one experimenter, while another experimenter stands near the food box ready to time the run.

Our question is whether the rat learns the maze by observation (it would have to be hindsight) or by the cumulative effect of successful and unsuccessful movements. Otherwise put, the question is *what* the rat learns. The answer may be found by modifications of the maze experiment.

The *chain reflex theory* supposes that the animal learns a fixed series of movements. At first his movements have no definite order, and many of them, made in entering the blind alleys, are superfluous. These useless movements being gradually eliminated, what remains is a regular chain of movements, each of which is supposed to furnish the stimulus required to arouse the next movement in the chain. This theory is disproved by the following experiment. A maze was so constructed that it could be flooded with water, either shallow water through which the rat waded or deep water which forced him to swim. After an animal had learned the right path to the goal while wading, he followed it correctly when deep water forced him to swim; or *vice versa*. Though wading and swimming movements are quite different, the shift from one to the other did not take away what he had learned. He had not learned a sequence of bodily movements; rather, he had learned a *path* through the maze (*19*).

The *fixed path theory* is not adequate, either. Several modifications of the maze experiment prove that the animal learns more than that. In a maze provided with two or more alternative routes he takes sometimes one path and sometimes another, showing a preference however for the shorter or easier of two paths. Still another modification of the experiment is very instructive. It answers the question whether the rat would learn anything if he wandered through the maze time after time without being rewarded by food in the food compartment. Three groups of rats were compared. The rats of the first group were rewarded, as is usual, by food in the food box on every trial; their learning curve showed the usual gradual improvement. Another group ran for ten trials without any reward except that of being taken out when they reached the empty food box. They continued exploratory behavior throughout these ten trials. On the eleventh trial they found food, and from then on they showed the eager, goal-seeking type of behavior and mastered the correct path very quickly, proving that they had

learned the maze to quite an extent before they started to learn any fixed path.

One group of rats found food the first ten trials and then the reward was discontinued. They quickly dropped back into the exploratory type of behavior and wandered freely

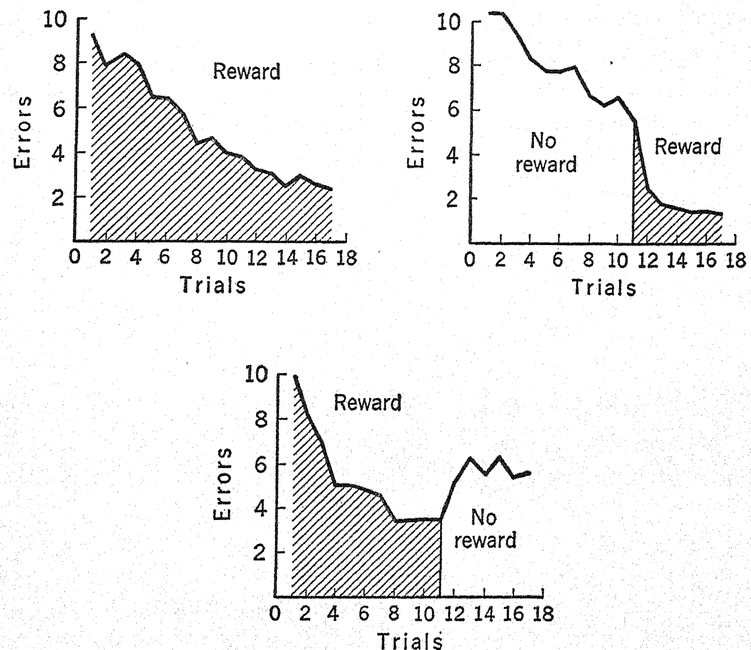

Fig. 59.—(Tolman & Honzik, *31*.) Learning curves of three groups of rats, the first group being rewarded at every trial, the second group not until trial no. 11, and the third group having no reward from trial no. 11 on. The errors, consisting of entrance into blind alleys, become fewer as the rat masters the maze.

into blind alleys. They were not bound to the correct path just by virtue of having learned it.

From these experiments we may conclude that a rat becomes well acquainted with a place by exploring it, even if he has no definite goal to steer for; but when there is a goal he steers for it. *What* the rat learns is primarily the maze, the locality; within this locality he learns a path to the goal.

The *place learning theory* is suggested by all the facts and

probably is not far wrong. The "place" which a rat learns is not merely spatial, for if the experimenter, between trials, changes the material of the floor in some passage, without altering the space relations in the least, the rat pauses and sniffs at the novelty. He is learning things-in-their-locations. He learns a *field of objects* that have certain characteristics and certain positions. He learns one or more definite paths through this field. If he runs the same path many times he may come to run it in a stereotyped manner suggestive of the chain reflex. But the order of learning is: first the locality, then the path, and finally (if at all) the stereotyped series of movements.

The discrimination experiment. In order to broaden our view of animal learning we need to use a variety of problems. The discrimination problem is such that foresight is absolutely impossible. The animal is placed in an entrance compartment with two doors side by side in front of him. One door is the "right" door and admits him to a food box; the other is "wrong" and is locked or admits him only to a blind alley. If the experimenter arranges to have the "right" door always on the right or always on the left, a rat learns to choose correctly in a very few trials. He learns simple locations quickly. But if the correct door is indicated by a signal, such as a light burning over the door, and if the correct door with its signal is changed irregularly from side to side, it may take the rat several hundred trials to learn this trick.

By chance the animal would make about 50 percent of right choices, since the chances are even for going right or wrong until he picks up the rule imposed by the experimenter. In many instances, after running along at the 50 percent level for many trials, the rat rather suddenly advances to nearly 100 percent of correct choices (*16*, *17*). He thus meets the ordinary criterion of insight. It must be hindsight and not foresight, since the rule is perfectly arbitrary and not to be discovered by even the most penetrating inspection of the setup. It can be discovered only by trial and error.

Sometimes the rat's behavior shows a peculiarity that has been called "vicarious trial and error." He hesitates before the two doors, advancing a little toward one and toward the other before making his choice. He does not do this at the beginning but only after a number of trials; he does it most in the critical period when he is advancing rapidly from chance success to complete success; and it is demonstrably an aid in learning. It seems to be a way of getting a lead. Human beings sometimes show similar behavior (*7, 22, 30*).

The delayed reaction experiment. This is an extension of the discrimination experiment, the question now being whether the animal, after thoroughly learning to obey a certain signal, can still obey it though it disappears before he is free to approach the designated door. The animal is held back as long as the signal shows and is released after some delay. The delay is lengthened till his reaction breaks down. With a setup of three doors side by side, the maximum delay was about 10 seconds for rats, and 5 minutes for dogs (*13*). The rats failed altogether unless they kept their bodies or heads pointed toward the designated door or struggled to go in that direction. Some dogs, however, could move about during the interval of delay without losing their cue.

The delayed reaction test has been tried on monkeys with striking results. The experimenter places two inverted cups on the floor and lets the monkey see him place a piece of banana under one of them. Both cups are then concealed by a large screen for a certain interval, after which the screen is removed and the monkey told to "go get the food." With few errors, the monkey promptly chooses the correct cup, even when the delay is extended to several hours during which the monkey is out of the room (*29*).

The rat pointing at the designated door during the interval of delay shows *goal set* in a perfectly concrete, visible form. The monkey looks sharply at the cup while the experimenter is placing the banana under it, and undoubtedly locates that cup in the "field of objects." So he becomes set or adjusted

for the location of the goal. He is able to renew this adjustment when he returns to the situation.

Adaptation or situation set. An animal must be habituated to laboratory conditions before he makes a good subject in a learning experiment. Before starting a maze-learning experiment, the psychologist will place the animal in some form of maze or similar enclosure a few minutes every day for a week, feeding him there. This period of adaptation enables the animal to make much more rapid progress in learning than if he were taken from his living cage without any preliminaries and placed at once in the maze to be learned. He has lost his timidity and is free to start exploring the new maze at once (*34*).

Negative adaptation eliminates a response when the animal has got used to the stimulus. It is illustrated by a famous old experiment on a spider. While the spider was on its web, a tuning fork was sounded, and the spider made its regular defensive response of dropping on its thread. When it had climbed back to its web, the fork was sounded again and the spider dropped again; but after several repetitions in quick succession it ceased to drop. Next day, to be sure, it responded as at first, but after several days of this training it dropped no more and was permanently adapted to the sound (*24*).

Negative adaptation is seen in domestic animals. The horse gets used to the harness, and the dog to the presence of the cat in the house. Taming consists largely in accustoming the animal to handling that at first arouses fear or a vicious attack. Man also becomes adapted to recurring but unimportant noises and other stimuli—so well adapted that he scarcely notices them. Negative adaptation, then, eliminates responses that are not worth the trouble. It leaves the individual free to deal with the important things and is an essential part of good adjustment to any continuing situation. It is part of any complete situation set (p. 35).

Summary so far. All the facts that have been brought forward on animal learning can be rather simply stated. Placed in a novel situation the animal explores and comes to know

the situation in the practical sense that he is adjusted to the place and the things present there. If he finds something worth having in the situation he becomes set for that thing as a goal, and his further explorations are directed toward the goal. He finds possible leads to the goal—such leads as alleys, spaces, doors, bolts, sticks for reaching—and tries these leads, finding some of them good and others worthless. So he gets acquainted with the things present and with their useful or useless characteristics for reaching his goal. "Getting acquainted" means observing while exploring and trying leads. The animal's observations, however, are often vague and superficial as compared with those of a human being.

Such, at least, is one reading of the facts. We next turn to an instance of learning that is often regarded as very fundamental and as entirely devoid of anything like observation.

The conditioned response. About the year 1900 the Russian physiologist, Pavlov, while engaged in the study of digestion, using dogs as subjects, devised a method for measuring the flow of saliva. The duct of one of the salivary glands was made to discharge on the outside of the dog's cheek where the saliva could be collected as fast as it was secreted. Pavlov noticed saliva flowing not only when food was in the mouth but also when the dog saw food before him, or saw his food dish, or saw the man who usually fed him, or even heard the footsteps of that man in the adjoining room. The flow of saliva when food is actually in the mouth is a natural reflex, but when aroused by such stimuli as the sight of a dish or the sound of footsteps it was obviously an acquired response, dependent on the conditions under which the animal had previously been fed. Pavlov therefore called it a "conditioned reflex." Not being a reflex in the strict sense it is better called a conditioned response. It is a learned response (*23*).

Establishment of a conditioned response. In the hope of discovering how such responses were acquired Pavlov attempted to "condition" the salivary response to an arbitrary stimulus like the sound of a bell or a touch on the skin. He succeeded by the following procedure.

A hungry dog—a well-treated animal, fully at home in the laboratory—was placed standing on a table with slings under his body that prevented his walking away. After the animal had become quiet, an electric bell was started, and food was placed in his mouth when the bell had been ringing for a certain time, as 15 or 30 seconds. A pause of a few minutes intervened and then exactly the same combination of stimuli was repeated; and so on, time after time. After several repetitions of the sequence:

bell . . . . food

the saliva began to flow during the ringing of the bell and *before* food was given. The amount of saliva flowing at the sound of the bell increased trial by trial up to a certain maximum which, it is important to note, was much smaller than the flow produced by food in the mouth. Thus the conditioned salivary response was established for that particular occasion.

Next day there was no flow of saliva at the first sounding of the bell, but it appeared after a few repetitions; and a few days of this procedure established the conditioned response so thoroughly that it held over from day to day.

Though Pavlov's interest centered in the flow of saliva, which he could measure, he noticed a conditioned motor response accompanying the glandular response. While the bell was sounding, and before the food was given, the dog turned his head toward the source of food. The total conditioned response, motor and glandular parts included, was in effect a preparation for the reception of food. It was a pre-feeding act, a behavioral anticipation (whether conscious or not).

Extinction of a conditioned response. We are not to suppose that even a "well established" conditioned response has the fixity of a natural reflex. It can be trained out as it was trained in. Simply apply the artificial stimulus repeatedly without the natural stimulus. In one of Pavlov's experiments, the salivary response to a beating metronome was first well established, and then, on a certain day, the metronome was

sounded for 30 seconds, bringing a large flow of saliva, but no food was given. On the next trial, three minutes later, the flow was less abundant. Still no food was given, and the same procedure was repeated till the metronome failed to excite any salivary response. The gradual decrease and final extinction of the conditioned response can be seen in the following table of results:

Stimulation by the Metronome Began	*Quantity of Saliva Produced, in Drops*
12.07 P.M.	13
12.10 "	7
12.13 "	5
12.16 "	6
12.19 "	3
12.22 "	2.5
12.25 "	0
12.28 "	0

Such extinction is only temporary, for next day the metronome again gives a flow of saliva. But if food is omitted this day also, the extinction is more rapid; and repetition of the extinguishing procedure, day after day, finally causes a permanent disappearance of the conditioned response.

Extinction may be fundamentally the same process as negative adaptation. In both we see the gradual elimination of a useless response to a constantly repeated stimulus.

The delayed conditioned response. Let the bell always ring for 60 seconds before food is given. Early in the process of training the flow of saliva starts almost immediately and flows for the whole minute; but as the training progresses, day after day, the beginning of the salivary response is more and more delayed till it only shortly precedes the food. During the first half minute or more the dog slumps drowsily in his harness and no saliva flows; toward the end of the minute he brightens up and saliva begins to flow. He has become adjusted to the time schedule.

Differentiation of the conditioned stimulus. The bell in our example is the conditioned stimulus. The conditioned response, especially when newly established, is likely to be touched off by any stimulus that resembles the one used in conditioning. The conditioned response is "generalized" at the outset. If a tone has been used, a higher or lower tone will also give the response; if a touch on the shoulder has been the conditioned stimulus, a touch on the flank can be substituted. Can the response be restricted to bell *A*, for example, and withdrawn from bell *B*? Intersperse the two stimuli, always giving food with *A* and never with *B*. The salivary response to *B* is gradually extinguished while it continues with *A*. In effect, two conditioned responses are thus established: the positive response to *A* consists of brightening up and salivating, and the negative response to *B* consists of slumping down and not salivating. The one is an appropriate adjustment for getting food, the other for getting no food.

The need of good general adjustment in conditioning experiments. These experiments do not succeed unless the dog (or the sheep in some other experiments, *18*) is familiar with the experimenter and is well adjusted to the conditions of the experiment. Any unusual stimulus coming in causes the animal to investigate and disturbs his adjustment. It acts as a distraction and interferes with all of the effects that have been described. Pavlov found it so necessary to avoid all distracting stimuli that he had a special laboratory built for conditioned response work, with elaborate provisions for excluding all extraneous lights and sounds and even for keeping the experimenter out of the dog's immediate presence during an experiment.

Different conceptions of the conditioned response. There are several ways of interpreting the facts.

1. Anticipation. A sensible comment would be, "The dog is just like a person who hears the familiar dinner bell. He knows food is coming and his mouth waters in anticipation." But should we assume that the dog has the power of conscious anticipation? Are we not disobeying Lloyd Morgan's

canon? And if we tried to explain how the thought of food causes the mouth to water, we might find that lead pretty effectually blocked. We might decide that it was more hopeful to try to explain the human experience in terms of conditioning than to explain conditioning in terms of human conscious experience. Just the same, it is important to notice the anticipatory character of the conditioned response. It prepares the way for actual eating. Conditioning has built up an action pattern or sequence with the conditioned response (motor and glandular) as the preliminary stage leading directly into the final stage of eating.

2. *Substitute stimulus.* This explanation is purely physiological. It supposes that the outgoing part of a reflex, i.e., the muscular or glandular response, becomes attached to the conditioned stimulus. The conditioned response, accordingly, would be the same as the natural reflex, only attached to a new stimulus. The objection to this view is that the conditioned response is *not* the same as the natural response—not always, anyway. The conditioned salivary response differs from the reflex response to food in being much weaker. Besides, if we consider the motor part of the total response, we see a qualitative difference. The "brightening up" and turning the head toward the food are different from the movement of eating which is the motor response to food in the mouth.

3. *Set or adjustment.* When the environment is such that the sound of a bell is regularly followed by food, an advance flow of saliva shows that the animal is adjusted to that environment. When the situation changes and the bell is followed by no food, the extinction of the salivary response reveals an adjustment to this change in the environment. Differentiation and the delayed conditioned response also show that the organism is adjusting itself to the peculiarities of the temporary environment. All the experiments can be used as neat examples of situation set. The animal must be adjusted to the general situation before the experiment begins, and in the course of the experiment he becomes adjusted to the special characteristics of the situation.

4. *Conditioning as an example of learning by observation.* The word *observation,* as was said before, is rather too strong. All we mean is that the organism becomes impressed through the senses with the characteristics of the present situation, such as the regular sequence of bell and food. Being thus impressed the organism involuntarily makes an appropriate response (37).

Each of these conceptions gives us probably a glimpse at the truth, but no one of them is adequate. None of them, except the otherwise inadequate substitute-stimulus conception, pretends to explain how the conditioned response is *retained* from trial to trial and from day to day. In a vague way we can say that the brain is modified in conditioning, as in other kinds of learning.

HUMAN LEARNING

A comparison of human and animal learning, bringing out the particular ways in which man is superior, should throw some light on the difficult problem of how learning occurs. Quite obviously man learns much more than the animals, and the question is what he learns that animals cannot learn and in what respects his methods of learning are more efficient.

In the first place it is certain that man continues to utilize all the animal ways of learning. He often attacks a problem by trial and error, he becomes conditioned, he becomes negatively adapted to unimportant stimuli. If animals learn by observation, still more does man. His more intellectual methods would not be possible unless he had the primitive sort of learning as a foundation on which to build.

The conditioned response in human beings. Would experiments such as Pavlov's succeed with human subjects? Besides the salivary responses quite a number of others have been tried on children and adults. Babies given the bottle a few moments after the sounding of a buzzer show signs of conditioning after a few days of training; they stop crying at the sound of the buzzer, open their mouths and make sucking movements. Conditioning becomes easier as the

child advances in age up to about four years, but beyond that age the human individual *seems*, at least, to become progressively less easily conditioned. The *salivary conditioned response* can be established in some human adults but it is by no means as regular and dependable as in dogs. The human adult is likely to feel that he has been "fooled," that something has been "put over on him," when the experimenter causes him to do something he had no intention of doing. Some individuals object more seriously than others and the same individual's attitude may change from time to time. Consequently the conditioned response is undependable (*6, 20, 25*).

Though the adult human subject is rather undependable in conditioned response experiments, it would be a mistake to leave the impression that the experiments usually result in failure. Quite a variety of reflexes have been conditioned in one experiment or another.

Withdrawal. One natural reaction is to pull the hand away when it receives a strong electric shock. Bind the stimulator to the hand so that the shock cannot be avoided, and give a flash of light as a warning signal just half a second before the shock. Repeat the combination every half minute or so for an hour and you obtain conditioned responses in a large minority of college students. The conditioned response consists of an involuntary shrinking movement preceding the shock. It comes in very weakly at first and increases trial by trial. Some individuals try unsuccessfully to suppress it (*9*).

The *knee jerk* is a quick throw of the lower leg, produced by a sudden brief contraction of the large muscle in the front of the thigh, and elicited by a tap on the patellar tendon just below the knee. If this tap is regularly preceded by the stroke of a bell (coming a quarter of a second before the tap on the tendon), most adults sooner or later show some conditioned responses consisting of a relatively slow anticipatory contraction of the thigh muscle. Though the same muscle executes both the conditioned response and the natural reflex, the two movements are very different in speed.

The knee jerk is a spinal cord reflex, while the conditioned response is controlled by the brain (*27, 35*).

The reflex wink or *lid reflex* is a quick closing of the eyelids in response to any one of a large number of stimuli such as a sudden noise or a puff of air against the front of the eye. Apply a puff of air preceded by a weak flash of light and repeat the combination, always giving the flash ⅖ second before the puff. In the course of an hour nearly every subject will give at least a few anticipatory half-winks. Conditioning builds up a neat little pattern of lid movement, consisting of a slow, slight closure at the preliminary signal followed by the sharp, quick closure at the puff (*10*).

The *pupillary reflex* of the eye is a narrowing of the pupil when the light suddenly becomes brighter, a widening when it suddenly becomes dim. These relatively slow movements are executed by the "smooth muscle" of the iris and are ordinarily not under voluntary control. The subject is entirely unconscious of them, though of course he is aware of the changes in the light. To condition these movements to the sound of a bell or to the spoken commands, "Contract" and "Relax," is a long process but has been accomplished. Finally the subject can even make his pupil respond to his own silent commands. In effect he has obtained a measure of voluntary control over his iris muscle. Here we see voluntary control developing as the result of a process of conditioning (*12*).

Conditioned emotional responses will be considered in a later chapter (p. 379).

The human adult's ability and desire to exercise voluntary control over his responses indicate one important difference between animals and man. The animal is more naive, man more self-conscious. For this very reason the animal makes a good subject in the study of primitive learning.

Maze learning by human subjects. To adapt the maze for experiments in human learning, it may be reproduced on a large scale, but more commonly it is transformed into a hand maze, the hand pushing a stylus along through a groove, or the finger following a pattern of wire fastened to the surface of a board. Usually the human subject is blindfolded or

somehow prevented from looking down on the entire maze. Comparison of rats and men in learning the same maze pattern tends to increase our respect for the rat. Often the rat learns it in as few trials as the man. The rat makes more errors and enters the same blind alley several times on the first trial. The human adult is more deliberate and tries to check off the blind alleys as he discovers them so as not to repeat the same error. The most characteristic human devices in maze learning are the following:

1. The use of verbal aids, such as counting the turns and working out a scheme like "right, left, three right, two left," etc. Verbal aids are useful in fixing the details rather than in getting the general orientation and pattern of the path. In some forms of maze, those individuals who resort to verbal aids have a great advantage over those who rely on pure "motor learning" (*33*).

2. The use of visual schemes or imaginary maps. Comparatively few persons are able to make effective use of this device, but it is found that previous visual acquaintance with a maze greatly facilitates the subsequent blindfold learning of it (*32*).

3. The use of landmarks. The human subject gives definite testimony of noticing certain parts of the correct path, and of experiencing great satisfaction when he reaches them. They become intermediate goals and he is able to build his path upon them as he does also upon the beginning and end of the maze. He learns parts of the maze in this way and enlarges the parts till they meet. The parts are learned as parts of the whole maze, and a general adjustment to the maze as a whole, built up in the early trials, serves as a framework into which the parts are fitted. First get a general adjustment to the maze as a whole, and then work out the parts, fitting them together into the whole. Such seems to be the procedure of either rats or men in learning a maze (*4*).

The puzzle experiment with human subjects. In place of the simple puzzle-boxes used with animals, a mechanical puzzle is of suitable difficulty for the human adult. The

puzzle is to be taken seriously, and a "practice experiment" made, the trials being repeated until the subject can manipulate the puzzle quickly and uniformly with no errors or hitches in the performance. The experimenter notes the time required by the subject to take the pieces apart and observes his mode of attack, while the subject reports after each trial what he can remember of his efforts and difficulties.

The human subject's first attack on a puzzle partakes largely of trial and error. Impulsively he tries one possible opening after another, sometimes following the same false lead repeatedly, till, more or less by chance, the pieces come apart to his surprise and gratification. Some few individuals make a more deliberate attack and attempt to study out the puzzle without manipulation; but this apparently rational procedure seldom succeeds because the necessary three-dimensional movements of the pieces cannot be envisaged without actual trial. Rational procedure consists mostly in following through the leads, checking off those that prove futile, and watching for radically new suggestions.

In the second trial the subject may still be at a loss and proceed in the same haphazard manner as at first; but usually he has observed one or two helpful facts. He is most likely to have noticed at what part of the puzzle he was working when the accidental success occurred; for *locations* are about the easiest facts to observe—easiest for men as well as animals. In the course of a few trials the subject eliminates many of the false leads and perhaps "sees into" the puzzle more or less clearly, though he may learn to manipulate the thing correctly without really knowing what happens.

The insight that occurs in solving a three-dimensional puzzle is mostly of the hindsight variety. It need not be at all profound to be useful in solving the immediate problem. The more profound it is the wider is its sphere of possible application. One interesting question is whether *skill in manipulating* an object is acquired by observation. When the subject first succeeds in solving one of these mechanical puzzles his manipulation is awkward, but he acquires skill by repeated trials. Sometimes he reports noticing some charac-

teristic of the puzzle and being helped by this observation in his efforts to handle the puzzle smoothly and quickly. An instance is recorded in Fig. 60. To assert that all skill is gained by observation and that all learning is accomplished by observation is however going pretty far—much beyond the evidence now available.

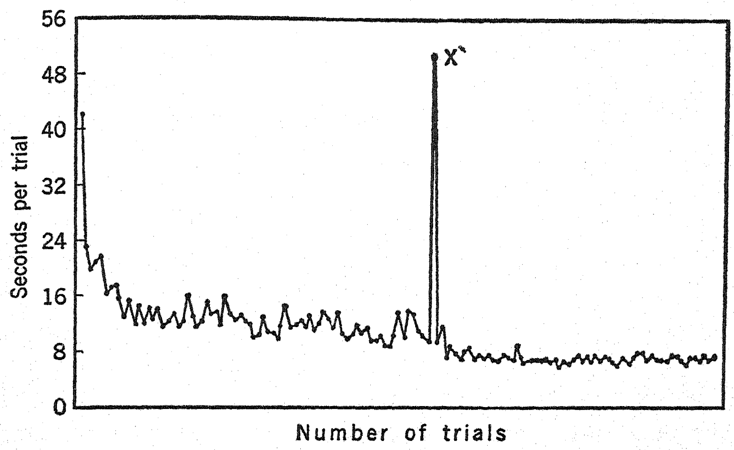

FIG. 60.—(Data from Ruger, *26*.) Learning curve of a human subject in mastering a mechanical puzzle. The trials are arranged in their order from left to right, the time taken in each trial being indicated by the height of the curve above the base line. Improvement is shown by the gradual descent of the curve. At the point X the subject observed something about the puzzle that he had not noticed before and studied it out carefully, so increasing his time for this one trial but permanently bettering his performance.

In understanding and handling mechanical things man's superiority to animals is very great. His hands are more suited for deft manipulation and, what is still more important, his power of observation is greater. He sees the relations of mechanical things much more clearly. Such problems as a door button or a jointed stick would offer no difficulty to an adult or half-grown child. Yet even in the peculiarly human field of mechanics man seems to have no knowledge apart from experience. The young child, fond as he is of manipulation, does not see into the properties of things at first (*14*). Even the simplest mechanical problem,

like taking his coat from a hook, is beyond him till he has experimented with it. He learns by "experience," which means manipulation combined with observation. By trial and error combined with hindsight he builds up a knowledge of mechanical things and becomes able to attack new mechanical problems with some degree of foresight.

Not only mechanical things but even social requirements are learned by the child through trial and error combined with observation, as we saw in the case of the group code of ethics (p. 183). After acquiring a fund of knowledge of these matters he is able to proceed with some foresight.

Summary of differences between human and animal learning. The main points of human superiority, so far as revealed by our comparison, seem to be the following.

1. Man is a better observer; he observes many characteristics of things, people and situations that lie beyond the animal's scope.

2. Man uses more deliberation, management and control in attacking a problem.

3. Man makes great use of names, numbers and in general of language in learning.

4. Partly by aid of language, man is able to think about problems even when the materials are not before him. After struggling vainly with a puzzle, a subject has been known to reach a solution while lying in bed the next morning. Ideation, the thinking of things that are not present to the senses at the moment, is doubtless much more highly developed in man than in any other animal.

THE LEARNING OF COMPLEX ACTIVITIES

We should fall far short of doing justice to human learning if we limited our survey to problems which can be mastered in a few trials. Piloting an airplane, playing a violin or any occupation in which master workmen, virtuosos and "aces" occur by the fortunate combination of natural aptitude and intensive practice, should be examined with the object of discovering what these experts really learn and by

what process they reach their high level of mastery. Such studies have been made of telegraphy and typewriting.

Higher units of performance. A student of telegraphy was tested once a week to determine how rapidly he could send a message, and how rapidly he could receive a message by listening to the clicks of the sounder. The number of

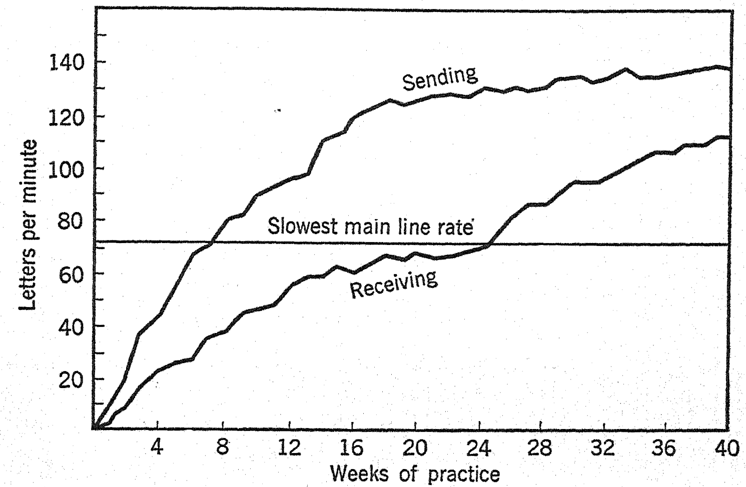

FIG. 61.—(Bryan & Harter, 5.) Learning curves of a student of telegraphy. The height of a curve above the base line shows the number of letters sent or received per minute. A rise of the curve here denotes improvement.

letters sent or received per minute increased rapidly in the first few weeks and then more and more slowly, giving a typical learning curve.

The curve for sending, aside from minor irregularities, rose in a single broad sweep and flattened out near the "physiological limit," the limit of what the nerves and muscles of this individual could perform.[1] The receiving curve rose more slowly than the sending curve and flattened out after four months of practice, with little further improvement during the next two months—a discouraging period for

[1] A good example of the physiological limit is seen in the hundred-yard dash, since apparently no one can lower the record much below ten seconds. Any given individual's limit may of course be far above this.

the student, for he seemed to have reached his limit before coming up to the commercial standard. Many learners drop out at this stage. But this particular student, persisting, found his curve making a fresh sweep upward. It went up rapidly for several months and before it again flattened out at a higher level it had brought him well above the minimum standard for regular employment.

Such a flat stretch in a learning curve followed by a second rise—such a period of little or no improvement followed by rapid improvement—is called a "plateau." Sometimes due to mere discouragement or carelessness, it often has a deeper cause. It may represent a true physiological limit for the act as it is being performed, and the subsequent rise to a higher level is then the result of *improved methods.*

It was found that the telegrapher acquires skill by improving his methods more than by simply speeding up his movements. At first he learns the letters in terms of dots and dashes. Each letter, in sending, is a little pattern of finger movements on the telegraph key, while in receiving it is a pattern of clicks from the sounder. When he has learned these little patterns, he is able to send and receive, though very slowly. In sending he spells out the words to himself and writes each letter as a separate act. In receiving, at this early stage, he dissects each letter pattern out of the continuous series of clicks coming to him from the sounder. With practice the letter patterns become so familiar that he goes through this spelling process easily, and concludes that he has mastered the technique and needs only to put on speed.

But not at all! He has acquired only a small part of the expert's technique. He has the "letter habits" but scarcely dreams of the possibility of "word habits." These emerge with further practice. The rhythmical pattern of a whole word becomes a familiar unit. No longer is the word spelled out in sending and laboriously dug out letter by letter in receiving; you simply think the word "train," and your finger taps it out as a complete pattern; or, in receiving, you recognize the characteristic pattern of a long series of clicks.

A few much-used words first become units to the learner, then more and longer words, till he possesses a large vocabulary of familiar word patterns. He finds this method of word patterns wonderfully superior to the spelling-out method. He does not even stop with word patterns, but acquires a similar control over familiar phrases (*5*).

It is much the same in learning to typewrite. First you

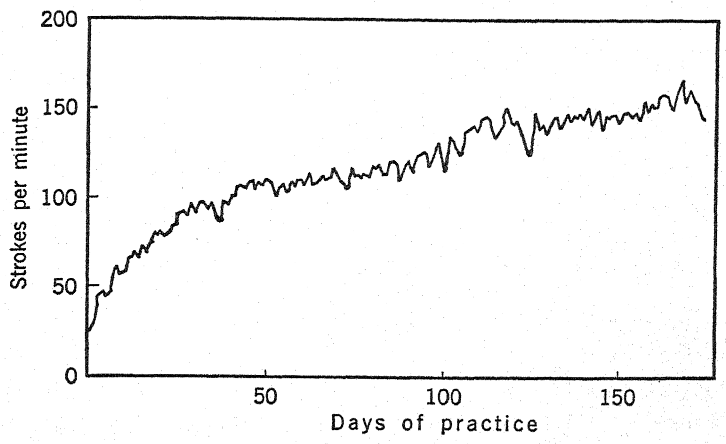

FIG. 62.—(Book, *3*.) Learning curve of a young man in typewriting. Each point on the curve shows a day's record in number of strokes per minute. A plateau extends from the 50th to about the 90th trial, after which there is more rapid improvement for a time.

learn your keyboard and where and with what finger to strike each separate letter. When the letter-striking movements have become easy and sure, you have reached the "letter habit stage," in which you spell out each word to yourself as you write it. With further practice you become able to write any familiar word without spelling it, by an integrated pattern of finger movements. You write mostly by word units, and in part even by phrase units; and these "higher units" give speed, smoothness and accuracy of performance (*3*). In telegraphy and typewriting, it is almost inevitable that the learner should master the letters before advancing to the higher units. But in learning to read, children can start with whole words or phrases, mastering the

higher units first and proceeding later to analysis of the larger into smaller units.

Practice does not necessarily make perfect. The higher levels of skill are not reached by half-hearted performance, no matter how often repeated. Monotonous repetition simply makes the lower-level procedure more automatic. The only escape to the higher levels comes in moments of intense interest and absorption in an activity. It was in such moments that the typewriting learner hit upon his word patterns.

In the ordinary day's work, we have no clear indication how well we are doing, no learning curve shows our progress, and we are satisfied if we get through the day easily and without much criticism. Consequently we reach only a moderate level of skill, nowhere near our physiological limit, and never acquire really expert technique. This is as true of the brain worker as of the manual laborer. Evidently motivation—to which topic we will come in a few chapters—is as important a factor in human learning as in that of the laboratory animal. The psychologist can supply motivation for his white rats more effectively than is usually done in human affairs.

ESSENTIALS OF THE LEARNING PROCESS

No single theory of learning would command the universal assent of psychologists at the present time. Approaching the subject from different sides they are impressed with different aspects of the process.

Association by contiguity. This famous old law stated that two ideas become connected by virtue of being experienced together. It is better put in a negative form: two ideas do not become associated except by being experienced together. Two "ideas" such as a person's name and face do not become associated in your mind except when you experience them at the same time. Even then they do not always become associated. Contiguity is not enough (p. 333).

Repetition. Another old law is that of *use and disuse:* an act is strengthened by use and weakened by disuse. Subordinate to this are the laws of *frequency*, *recency* and *intensity* or vividness. In stimulus-response terms they state that the more frequently, the more recently, and the more intensely a given stimulus-response unit has been used or exercised, the stronger it is and the readier for action. These laws fit well into our general conception of learning as the development of the individual through his own activity.

Of late years, many attacks have been made on the assumption that frequency, or repetition, is of itself favorable to learning. To be sure, the conditioned reflex is established only by dint of repetition, but it is also extinguished by repetition without the natural stimulus. The truth may be that repetition by itself neither strengthens nor weakens an act, but simply affords other factors a chance to exert their favorable or unfavorable influence. Accordingly it has been proposed that the way to break an undesirable habit is not to avoid repeating it, but to repeat it persistently and in cold blood. In line with this suggestion, the habit of writing "hte" for "the" on the typewriter has actually been eradicated by writing "hte" several hundred times, always with the thought that an error was being committed. Some success has even been achieved in curing stutterers by requiring them to practice voluntary stuttering that shall reproduce exactly their own involuntary stuttering. The hypothesis is evidently better than it appears at first thought (*8*).

Reward and punishment. Learning cannot be explained by repetition alone. In most instances of learning the factor of reward or punishment is clearly present. The food at the end of the maze, the electric shock in a blind alley, are factors of proved importance. Simple delay in a blind alley is punishment, as shown by the animal's selection of the shorter of two alternative routes. In human maze experiments, the mere success or failure in quickly reaching the goal are sufficient incentives. In establishing a conditioned salivary response, the food is reward, and in extinguishing the same response the absence of food amounts to punishment. Thus

reward and punishment play as important a part in conditioning as in trial and error learning.

We should not forget, however, that the rat learned the maze as a locality even when there was no food in the food box. What is the reward of mere exploration? Is knowing the locality—or adjustment to the environment—entitled to be called a reward? It certainly means freedom from timidity and uncertainty, and it means readiness for action in that locality. It means freedom to lie down and sleep if there is no call for action. Even negative adaptation is a reward, since it means freedom from unnecessary activity. Ease and readiness are certainly to be counted among the fundamental rewards. In one form or another, it would appear, reward and punishment are always present whenever any learning takes place.

Pattern forming. The higher units in telegraphy and typewriting, the rat's smooth run through a well-learned maze, the sequence of phases in the conditioned response—such patterns are found in all learned activities. In the learning of a performance, the action pattern is at first a mere framework—an orientation towards the goal—but it develops by incorporating parts into this framework. There is first a rather vague adjustment to the situation as a whole, and later, one by one, the various parts of the situation are found and located within the whole. Such a phrase as "fitting parts into a framework" conveys a true picture of the learning process.

Learning by observation. The importance of this factor has been sufficiently emphasized. If we ask what the individual learns, the answer is, "the situation and the things in it." He learns by using his senses and being impressed with the characteristics of the situation as he explores it and with the characteristics of objects as he manipulates them.

Motor learning. The proper movements may follow as a matter of course as soon as the situation is observed. Once the rat has been impressed with the blind-alley character of a certain passage, he keeps out of that passage without having to learn any new movements. If he has learned the path to

the food box, he does not have to learn also the sequence of movements required to follow that path. So far, we need not assume any motor learning. But when the rat runs the same maze many times, his run takes on a speed and smoothness that suggest a learned motor sequence. Man executes complex combinations of movement that run off almost automatically, once they get started. Speech movements are a good example. Man also executes simultaneous combinations of movements, movements of both hands, for example, that appear to work automatically. All these motor patterns may depend on observation in the first instance, but continued use seems to integrate them so closely in the nervous system that they get along with only a minimum of observational control.

We may believe, then, that there are two kinds of learning: by observing objects and by combining movements.

Summary of the chapter. Summaries of parts of the chapter have been given on pages 306, 310, and 318. The learning of many varied problems, by animals, children and adults, shows a good measure of similarity throughout. A novel situation must be explored and things in it manipulated, in order to be learned. Trial and error, in this sense, is always necessary. But the learner observes while exploring and manipulating, so becoming acquainted with things by hindsight and building up through such experience the basis for foresight in attacking subsequent problems. Man surpasses animals in observation, management, and the use of linguistic and ideational aids in learning. Human skill depends largely on the combination of smaller acts into higher units. The conditioned reflex turns out to be, not a mere attachment of an old response to a new stimulus, but a pattern of action adjusted to the character of a particular situation.

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Chapter X

Memory

WHEN the poets sing of the pleasures of memory, or sometimes of the terrors of memory, they are pointing to a human ability which is truly remarkable. The enjoyment of a fine vacation outlasts the trip itself indefinitely. To some extent, not completely of course, you can live your experiences over again and enjoy them a second time or a hundredth time. The friends of your earlier years are not wholly lost, for they come back to you in memory; and when old friends come together in reality their conversation is sure to bring back the old days.

An interest in practical efficiency as well as in the enjoyment of life would prompt the psychologist to undertake a serious study of memory. So much depends on a good memory in all walks of life, and especially in brain work, that it is no wonder students and business and professional men become worried about their memories and resort to memory-training courses in the hope of improvement. But just here scientific study is of great practical value, and the best way to go about improving one's memory is to know the facts and laws of memory.

In defining memory, we should first repeat what has been said before, that this noun is properly a verb. The real fact is "remembering." How does remembering differ from thinking? Both make use of past experience. Suppose that a problem—let us say a conundrum—is put to two persons, one of whom has heard it before and remembers the answer, while the other has to think it out. The latter uses past experience, putting two and two together to build up a solu-

tion, but the former has a ready-made answer, derived directly from past experience. Memory, then, is a direct use of what has been learned, while thinking is an indirect use of what has been learned. Remembering is performing a previously learned act, while thinking is doing something partially new.

The study of memory obviously is part of the general topic of learning. The same laws should hold good in memorizing and reciting a poem as in running a maze, performing a skilled act, or acquiring and executing a conditioned response.

Division of the subject. There are two ways of remembering: *recall* and *recognition.* Recall consists in reviving an experience or in reproducing previously learned material, whether this material be an incident, a fact, or an action. Recognition consists in knowing an object that has been experienced, in being acquainted with an object now because you previously became acquainted with it. You sometimes recognize a person without being able to recall when and where you have seen him. More can usually be recognized than can be recalled. Faces are recognized more easily than they can be recalled; and often a name cannot be recalled and yet is confidently recognized when heard. Yet sometimes you recall a name correctly, but think you have not got it right; here you recall without recognizing. More than once it has happened that a writer or musical composer has unintentionally plagiarized the work of another, by reproducing what he has read or heard without recognizing it. Recall and recognition are thus different enough to warrant separate consideration.

Remembering proves previous *learning;* and it proves also that what was learned has been *retained* during the interval between learning and remembering. We have then four main subtopics under the general head of memory: Learning, Retention, Recall, Recognition.

MEMORIZING, OR INTENTIONAL LEARNING

In a typical *memory experiment*, the subject first memorizes certain material; then an interval, longer or shorter, elapses during which he has nothing to do with this material; and finally his memory of this material is tested. Schematically:

Learning . . . . (Retention) . . . . Remembering

So far as possible, all the conditions—such as kind of material, length of lesson, rate of presentation, state and attitude of the learner—are under control. The material must at first be unfamiliar, partially at least, so that the subject will have something to learn. Wholly unfamiliar material can scarcely be found. Much use is made of relatively meaningless material, such as nonsense syllables, nonsense drawings, or arbitrary lists of words or numbers, but all kinds of material have been used in one experiment or another. The experimenter's purpose is to discover exactly what the subject learns and how he learns.

The immediate memory span. One of the simplest memory experiments consists in presenting lists of numbers, and discovering how long a list the subject can reproduce perfectly after one presentation. Lists of increasing length are used:

518
3296
70461
927358
4016372
24971306
176028395
6381470259
85079153624
082649138574

Several lists of each length should be tried, in order to allow for slips and flukes. An individual may have no trouble with

three, four or five numbers and may succeed every time with six and seven, and usually with eight, but only seldom with the longer lists. His "immediate memory span for digits" would then be approximately seven, about the average for a college student. Children of four to six years have a span of about four digits, and the average increases gradually up to the age of eighteen. It increases also with practice.

Memorizing of longer lessons. If the list of numbers to be memorized exceeds the memory span, several readings are necessary before it can be recited. Of course!—but it is really rather strange. Suppose your memory span is eight digits; why should you not be able to hold eight digits while reading another eight, and then recite the whole sixteen, after a single reading? There is some sort of interference. Grasping the second handful, or span of digits, loosens your hold on the first handful. We have here an important elementary fact of memorizing.

Another elementary fact comes to light if you go over the long list time after time. Though for a while it seems beyond your power, with *repetition* it becomes more and more familiar till finally it can be recited without error.

2 6 0 1 3 6 4 2 8 1 9 4 7 6 8 9 0 1 2 7

Mere repetition, however, does not describe the process of intelligent memorizing. The learner is very much on the alert. Suppose he has a list of twenty digits to memorize. As he wades into the long list and finds himself getting out of his depth, he grasps at anything to help. He does not simply take the numbers as they come but looks for *groups* that will hang together. Any familiar group, such as the sequence 1492, he hails with joy. Even if he finds no specially easy spots, he at least notes the *locations* of certain numbers and groups in the list, and he notes similarities and other *relationships* that tie the different parts of the list together.

This process of memorizing conforms very well to the formula suggested by maze learning—"fitting parts into a frame-

work." In memorizing a list, the learner starts with a general impression of its length and make-up, and he proceeds to find parts and to locate them in his framework. The beginning and end of the list, where locating is easy, are usually learned first, but landmarks are soon found in the middle also. The mastered portions grow and finally unite.

Lists of nonsense syllables, such as

wok pam zut bip seg ron taz vis lub mer koj yad

are usually learned by grouping, by observing similarities and contrasts, and by reading meaning into the single syllables or their combinations. Often the subject accents the first syllable of each pair, and finds that the *rhythm* thus introduced aids in memorizing. Many are the devices hit upon, and some of them work better than others, but they all reveal the learner as actively searching for combinations that shall be familiar, meaningful, or somehow characteristic, and thus useful in tying the items together, and in transforming the list from an amorphous mass into a well-articulated pattern.

Different types of memorizing. The learner's line of attack differs according to the particular test that is later to be made of his memory. Suppose an experiment is conducted by the method of "paired associates." The subject is handed a list of paired words, such as

soprano . . . . . . emblem
grassy . . . . concise
nothing . . . . . . ginger
faraway . . . . . . kettle
shadow . . . . . . next
mercy . . . . scrub
hilltop . . . . internal
recite . . . . shoestring
narrative . . . . . thunder
seldom . . . . harbor
jury . . . . eagle
windy . . . . occupy
squirm . . . . hobby
balloon . . . . . . multiply

necktie ...... unlikely
supple .... westbound
obey .... inch
broken .... relish
spellbound ... ferment
desert .... expect

He must learn to answer with the second word of each pair when the first word of that pair is given. The way he learns this lesson is to take each pair as a unit and look for something in it to bind it together—the mere swing or rhythm of the two words, or some connection of meaning. Perhaps the pair suggests a scene or action, however bizarre. A pair that gives a laugh is easy. A few readings fix most of the pairs.

But suppose the experimenter now springs a surprise, by asking the subject to recite the pairs in order. The subject fails almost completely, and protests that the test is not fair, since he has paid no attention to the order, but only to each pair by itself. Had he expected to recite the whole list, he would have noted relationships between one pair and another, and perhaps woven them into a continued story. The subject's failure in this last test shows that mere "contiguity" does not suffice to establish connections. The adjacent pairs were contiguous enough, but the learner did not bind them together. The two words composing each single pair, besides being contiguous, were understood to belong together, and the learner looked for something to hold the pair together. Learning a pair consists essentially in finding some unity in it.

The memorizing of a *connected passage* of prose or verse is greatly assisted by the familiar word-sequences and by the meaning of the whole. As a result, the passage is learned in a fraction of the time needed to memorize the same number of disconnected words. No one in his senses would try to memorize meaningful material by mere rote. To fix in mind the sense of a passage, the essential thing is to get the sense. If the main idea is clearly seen in the first reading, that main idea is already learned, though further read-

ings may be necessary to fit the subordinate thoughts into the main thought.

ECONOMY IN MEMORIZING

Memorizing is a form of mental work that is susceptible of management, and several principles of scientific management have been worked out that may greatly assist one in learning a long and difficult lesson. The problem has been approached from the angle of economy. Suppose a certain amount of time is allowed for the study of a lesson, how can this time be best utilized?

The first principle of economy has already been sufficiently emphasized: observant study, directed toward the finding and organizing of significant facts, is much more efficient than mere dull repetition.

The value of recitation in memorizing. "Recitation" here means reciting to oneself. After the learner has read his lesson once or twice, let him attempt to recite it, prompting himself when he is stuck. The question is whether this active method of study economizes time, and whether it fixes the lesson durably in memory. The matter has been thoroughly tested and the answer is unequivocally in favor of recitation. The results of one series of experiments on this matter are summarized in the adjoining table (p. 335).

Two facts stand out from the table: (a) Reading down the columns, we see that recitation was always an advantage. (b) The advantage was present in the test conducted four hours after study as well as in the test immediately following the study. Recitation favors permanent memory.

What is the advantage of recitation? For one thing, it is more stimulating than the continued re-reading of the same lesson. The latter procedure easily degenerates into a meaningless reading of the words which contributes very little toward learning the sense of a passage. Each recitation shows you what you already know and what still demands close attention. It makes you more observant.

THE VALUE OF RECITATION IN MEMORIZING (7)

Material studied	16 nonsense syllables		5 short biographies, totaling about 170 words	
	Percent Remembered		*Percent Remembered*	
Distribution of Learning Time	*Immediately*	*After 4 Hours*	*Immediately*	*After 4 Hours*
All time devoted to reading	35	15	35	16
1/5 of time devoted to recitation	50	26	37	19
2/5 of time devoted to recitation	54	28	41	25
3/5 of time devoted to recitation	57	37	42	26
4/5 of time devoted to recitation	74	48	42	26

The time devoted to study was in all cases 9 minutes, and this time was divided between reading and recitation in different proportions as stated at the left. Reading down the first column of numbers, we find that when nonsense syllables were studied and the test was conducted immediately after the close of the study period, 35 percent were remembered when all the study time had been devoted to reading, 50 percent when the last 1/5 of the study time had been devoted to recitation; and so on. The next column shows the percents remembered four hours after the study period. Each subject in this experiment had before him a sheet of paper containing the lesson to be studied, and simply read till he got the signal to recite, when he started reciting to himself, consulting the paper as often as necessary, and proceeded thus till the end of the study period. The subjects in this particular experiment were eighth grade children; adult subjects gave the same general results.

Continued re-reading does not at once give you the joy of success nor the pain of failure. Recitation applies reward and punishment earlier in the game.

If attempted too soon, recitation of course wastes time. The material should first be explored to see what it con-

tains. Then take a chance at recitation. So you find out more about the material, just as you learn about a mechanical puzzle by observantly manipulating it.

One form of recitation, especially valuable when the *substance* rather than the words of a passage is to be learned, consists in outlining the thought after a single reading. A second reading can be used to fit the details into the outline.

Spaced and unspaced repetition. Another question on the economical management of learning: Is it better to study a lesson without interruption till it is mastered, or to review it at intervals? This question also has received a fairly definite answer from the experimenters.

Spaced repetitions are more effective than unspaced, provided the lesson is a long one. You can memorize a list of 12 digits more quickly by keeping right at it till it is learned, but with a list of 20 or more it is economical to allow at least a 10-minute interval between readings, and a 24-hour interval is fully as good (*12*, *17*). Undoubtedly, in memorizing a long poem or speech, you would get better value for time spent by giving it one or two readings a day than if you attempted to finish the job at a single sitting.

Spaced study also fixes the matter more durably. Every student knows that continuous cramming just before an examination, while it may accomplish its immediate purpose, yields little permanent knowledge.

When we say that spaced repetitions give the best results in memorizing, we do not mean that study should be in short periods with intervals of rest. The probability, since most students consume some time in getting "warmed up" to study, is that fairly long periods of consecutive study will yield larger returns than the same amount of time divided into many short periods. What we have been saying here is simply that repetition of the *same material* fixes it better in memory, when an interval elapses between the repetitions.

Whole versus part learning. In memorizing a long lesson, is it more economical to divide it into parts, and study each part by itself till mastered, or to keep the lesson entire and

always go through the whole thing? Most of us would probably guess that study part by part would be better, but experimental results have usually been in favor of study of the whole.

If you had to memorize 240 lines of a poem, you would certainly be inclined to learn a part at a time; but notice the following experiment. A young man took two passages of this length, both from the same poem, and studied one by the whole method, the other by the part method, in sittings of about thirty-five minutes each day. His results appear in the table.

LEARNING PASSAGES OF 240 LINES, BY WHOLE AND PART METHODS (*18*)

Method of Study	*Number of Days Required*	*Total Number of Minutes Required*
30 lines memorized per day; then whole reviewed till it could be recited	12	431
3 readings of whole per day till it could be recited	10	348

In this experiment, the whole method gave an economy of 83 minutes, or about 20 percent, over the part method. Other similar experiments have given smaller differences, and sometimes the advantage has been with the part method. Sometimes, we should add, spaced learning has been found less economical than unspaced.

These contradictions in the experimental results warn us against accepting either spaced learning or whole learning as necessarily advantageous under all circumstances. Rather, we should analyze out the factors of advantage in each method, and govern ourselves accordingly. Among the factors involved are the following four:

1. The factor of interest and confidence. This is on the side of part learning, especially with beginners, who soon feel out of their depth in a long lesson, and lose hope of ever

learning it as a whole. This factor is also often on the side of unspaced as against spaced learning, when there are recitations to keep up the interest; for when the learner sees he is getting ahead, he would rather keep right on than wait for another day to finish.

2. The factor of recency, of "striking while the iron is hot." When an act has just been successfully performed it can easily be repeated, and when a fact has just been observed it can readily be put to use. This factor is clearly on the side of unspaced learning.

3. The factor of meaning, outlining and broad relationships. This is on the side of whole learning, for it is when you are going through the whole that you catch its general drift and see the connections of the several parts and their places in the whole. Even if you incline to the part method, one careful reading of the whole is probably the best way to begin. So you can locate the parts that call for minute examination.

4. The factor of "growth through activity." This is on the side of spaced learning. The muscles certainly profit more from exercise with intervals of rest than by a large amount of continuous exercise, and no athlete would think for a moment of training for a contest by "cramming" for it. The brain, apparently, obeys the same law as the muscles, and for that reason spaced learning gives more durable results than unspaced.

In practice you need to follow principles rather than mechanical rules. You need to exercise some freedom in applying the results of experiment. If you have a great deal of memorizing to do—whether verbatim or for substance only—spaced whole study is a good general principle. But you should feel perfectly free to interrupt this regular procedure and concentrate for a time on some detail that can be mastered by a little intensive work. Some poise and skill are needed to handle the whole method efficiently. Anyone who finds the part method so much more comfortable that he prefers it at all odds should at least divide the material into fairly large parts, much larger than his memory span. If

you can recite two lines of a poem after a single reading, it will do you little good to keep on reciting this bit time after time. It would be much better to make four lines the unit. Even if you prefer the part method, it is best to begin with one or two careful readings of the whole and to review the whole occasionally, so providing a total framework into which the parts will fit as they are mastered.

The will to learn. What we have been examining is intentional memorizing, with the "will to learn" strongly aroused. The assertion has sometimes been made that the will to learn is necessary if any learning is to be accomplished. We must look into this matter, for it has an important bearing on the whole question of the process of learning.

There is a famous incident that occurred in a Swiss psychological laboratory, when a foreign student was supposed to be memorizing a list of nonsense syllables. After the list had been passed before him many times without his giving the expected signal that he was ready to recite, the experimenter remarked that he seemed to be having trouble in memorizing the syllables. "Oh! I didn't understand that I was to learn them," he said, and it was found that, in fact, he had made almost no progress towards learning the list. He had been observing the separate syllables, with no effort to connect them into a series.

The experiment described a few pages back on "paired associates" is another case in point. The subjects memorized the pairs, but made no effort to connect the pairs in order, and consequently were not able later to remember the order of the pairs.

Similar experiments on the *reliability of testimony* have shown that the testimony of eye-witnesses is very unreliable except for facts that were definitely noted at the time. Enact a little scene before a class of unsuspecting students, and later quiz them on the facts that transpired before their eyes, and you get an astonishing amount of hazy and even false testimony.

These results all emphasize the importance of the will to learn. But there is another side to the question. An event

occurs before our eyes, and we notice certain facts, not with any intention of remembering them later, but simply because they arouse our interest; but later we recall these facts with great sureness. We hear a tune time after time, and come to be able to sing it ourselves, without ever having attempted to memorize it. Certainly the little child learns much in his play and in watching people and things, though with no definite intention of learning.

What is the difference between the case where the will to learn is necessary and the case where it is unnecessary? In the one case the fact would not be observed, nor would the act be performed, except for the desire to learn it for future use, whereas in the other case the fact is observed or the act performed for some other reason. In both cases the learning consists in observing the fact or performing the act—performing it observantly.

RETENTION

So far we have been considering the process of learning, or "committing to memory." We come now to the second of the four main divisions of the subject and ask how we retain what we have learned. Retaining is certainly not a continued repetition of the learned performance. The boy who has learned to say the multiplication table, and also to turn a handspring, does not have to keep on performing these acts "unconsciously" in order to retain them. He retains them even while sound asleep. Retention is an inactive state of the learned performance. What is retained during the inactive state must be something in the way of *structure*. Activity has left behind it some modified structure of the organism, mostly modified brain structure. This modified structure is often called the *memory trace*. We do not know the exact nature of this trace, since we cannot observe it directly, but we have a right to assume that every process of learning leaves behind it some slight change in the brain structure which persists, for a time at least, and makes it possible later to remember what has been learned. We need

not assume the memory trace to persist forever. It may die out gradually with the result that what was once learned is finally forgotten.

But is anything once learned ever completely forgotten and lost? Some say no, being strongly impressed by the occasional recovery of memories that were thought to be gone forever. Experiences of early childhood have sometimes been recovered after a long and devious search. Persons in a fever have been known to speak the language of their childhood which in their normal state they could not remember at all. Such facts have been generalized into the extravagant statement that nothing once known is ever forgotten. For it is an extravagant statement. It would mean that all the lessons you ever learned, all the stories you ever read, all the faces, scenes and happenings that ever attracted your attention are still retained and could be recalled if only the right means were taken to revive them. There is no evidence for any such extreme view.

How to observe and measure retention. Since we cannot see the memory trace, our only evidence of retention is obtained from the fact that what has been learned can be remembered after an interval. You can prove that you remember a lesson in three ways. You can *recall* the content of the lesson, as in the "essay type" of examination. You can *recognize* statements taken from the lesson, and distinguish them from statements not contained in the lesson, as in the "true-false" examination. These two methods are often used in testing retention. There is a third, less obvious method, called the *relearning method.* If some time ago you memorized certain stanzas of a poem, it may be that you cannot now recall any of the lines; it may be you cannot even recognize or identify the stanzas you once learned; but you may find that you can now learn certain stanzas quite easily, because you are *relearning* what you learned before. If it took you 10 minutes to memorize a stanza originally, and now takes you only 8 minutes to relearn it, retention is responsible for a saving of 2 minutes in relearning. The labor of relearning has been reduced by 20 percent through

retention of the effects of the former learning, and the retention, as measured by the *saving*, amounts to 20 percent.

The retention curve, or "curve of forgetting," was first obtained by the relearning method and later verified by use of the recall and recognition methods. The curve shows a gradual loss of retention with the lapse of time. But the rate of forgetting is not constant; rather, it is rapid at first, immediately after the end of the learning, and becomes slower and slower.

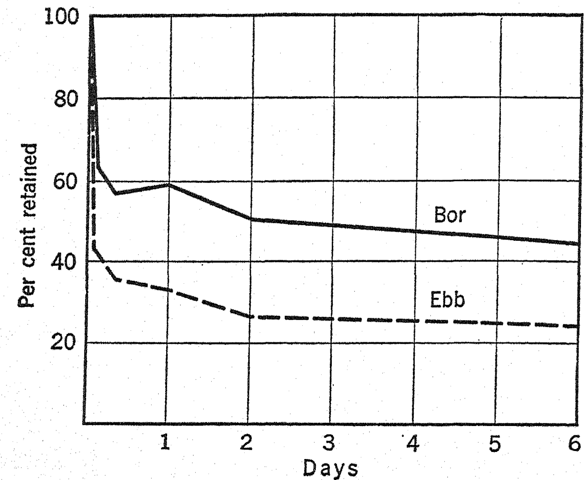

FIG. 63.—(Ebbinghaus, *5*, and Boreas, *3*.) The curve of forgetting, or curve of retention. Lists of nonsense syllables were memorized, laid aside, and relearned after the stated intervals. The percent retained was measured by the saving in relearning. The Ebbinghaus curve (Ebb) is from one practiced subject who learned many lists; the Boreas curve (Bor) is the average from 20 students, each learning and relearning one list for each interval. While the Boreas curve shows much slower forgetting than that of Ebbinghaus, both curves have the same general course.

Though the general shape of the curve is well established by numerous experiments, the absolute speed of forgetting varies enormously in different cases. (a) One individual forgets more rapidly than another. (b) Material that has been "overlearned," i.e., studied beyond the point where it can barely be recited without error, is forgotten more slowly. (c) Most important of all, meaningful material, besides being

much more quickly learned than nonsense material, is much more slowly forgotten. Nonsense material, barely learned, is almost entirely lost by the end of four months, but poetry, barely learned, has shown a perceptible retention after twenty years. Material that is both meaningful and greatly "overlearned" may stick almost indefinitely with little apparent loss. A student who had practiced on the typewriter for two hundred hours, and then dropped it entirely for a year, recovered all the lost ground in less than an hour of fresh practice, so showing a retention of over 99 percent.

The causes of forgetting. Forgetting cannot be due to the mere lapse of time. It is not time, but only what occurs in time, that produces effects. Nor can the mere disuse or inactivity of any structure be supposed to have any effect. It must be a process of some sort which weakens the memory trace. Two quite different processes suggest themselves, and psychologists are not agreed as to which is the more important. There are, in fact, two theories of forgetting.

1. Atrophy through disuse. Though mere inactivity of a structure is not a force or cause that could do anything to the structure, the memory trace, like any biological structure, needs to be kept alive and well nourished. A muscle certainly loses strength and substance when it is inactive for a long time, as happens when a broken arm is kept in a splint. The inactive muscle loses out in the competition for nourishment that goes on all the time in the organism. When a muscle has just been active it is in a state that may be called "hungry." It sucks up nourishment from the blood. It does not do this during prolonged inactivity but, on the contrary, loses substance to the blood. So the muscle grows as the result of its activity and atrophies from disuse. There is no reason why the delicate brain structures built up in learning should be exempt from this general biological law.

2. Interference. In waking life we are continually changing our activity. Every moment we do something different. If every act were controlled by its own small center in the brain, there would be no interference and no reason why the performance of one act should disturb the structure con-

cerned in another act. But we know (p. 286) that the brain acts in wide-spreading patterns rather than in small, separate bits. The patterns used in different acts may overlap and coincide in part. Consequently there is a chance for interference. The brain pattern built up in learning one act may be disturbed by the subsequent performance of another act—

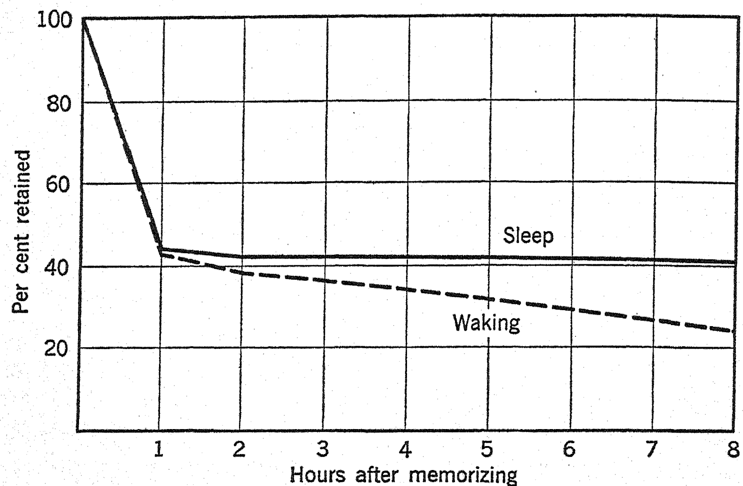

FIG. 64.—(van Ormer, *21*.) Retention in sleep and waking hours. The subjects, after memorizing lists of nonsense syllables, either went about their daily activities or else went to sleep as soon as possible and were awakened after a certain interval to relearn the lists. Forgetting was more rapid during waking hours than during sleep.

especially, we may suppose, if the two acts are similar. The reasonableness of this theory can be brought home to us by trying to recall *all* the views we have seen during a trip through the mountains. One view seems to wash out another, leaving only a few outstanding ones in memory.

As the two factors of disuse and interference are probably both real, we cannot hope to decide between them. Certain experiments do indicate the importance of interference.

Slow forgetting during sleep. The results of one experiment are given in Fig. 64. Other experimenters have obtained similar results. It appears that forgetting is more rapid during the day than during a night's sleep, as if the activities of

the day tended to disturb and obliterate the memory traces. This finding is subject to certain restrictions. First, it is *barely learned* material that shows this effect; better learned material is remembered practically as well after eight hours of ordinary daytime activity as after eight hours of sleep. Probably, we may suppose, a strong trace resists interference where a weak trace would succumb. Second, so far as we know the interference disturbs only *newly formed* traces. There is a very practical question here which has not been adequately attacked by experiment: Must the sleep follow immediately after the learning in order to have its beneficial effect on retention? Will a lesson learned immediately before retiring (or before becoming drowsy) be retained especially well? The evidence on this point is too scanty to warrant any practical rule. In deciding for himself, each individual would need to take account of his learning ability at different hours of the day. If one learns very slowly in the evening it would be poor economy to delay the important learning jobs till that time of day. A scheme that is probably good for many persons is to go over the lesson once in the evening and once more next morning, so combining the advantages of whole learning, spaced learning, sleep after learning, and early morning freshness.

Retroactive inhibition. The term "inhibition" is used to mean the checking of one activity by another. It is practically the same thing as interference. "Retroactive" means literally an influence of what follows on what precedes. In the strict sense any such influence is unthinkable, but what is meant here is that the *trace* left behind by the earlier activity is impaired by a subsequent activity. Since sleep after learning favors retention, we should expect that a few minutes of "taking it easy" directly after learning a lesson would make for better retention than an equal period devoted to strenuous mental activity. Experiments show that such is the case. For example, the position of five chessmen on the board was examined for 15 seconds, and the following minute was spent in adding columns of figures. After this the subject attempted to replace the chess pieces in their original

positions, but made 50 percent more errors than when he simply rested during the interval (*20*). In another experiment the subjects first memorized a list of 16 adjectives and then either (a) spent the next 20 minutes in reading humorous anecdotes, or else (b) first learned another similar list of adjectives and read anecdotes for the remainder of the 20 minutes. At the end of this interval they attempted in both cases to recall the original list of adjectives; the score was 8 words recalled after rest, but less than 4 recalled after work, on the average of 40 college students who served as subjects in this experiment. Retroactive inhibition lowered the retention by over 50 percent (*13*). Many similar experiments have been tried and on the whole they show more or less of retroactive inhibition, though sometimes the effect is very slight. The greatest loss of retention is obtained by shifting directly from one lesson to another consisting of very similar material.

The practical inference is clear. It pays to relax for a few moments after intense study and let the learned material "soak in." This expression, "soak in," implies a theory which many psychologists are unwilling to accept. It is called the *consolidation* theory, and the idea is that the process of forming a memory trace continues for a short time after the active learning ceases. For a few minutes after a trace is formed, it is young and tender and easily disturbed. If left undisturbed it hardens or consolidates and can resist later interference. The objection raised to this theory is that it does not explain why very *similar* activity after learning a lesson should exert the greatest amount of retroactive inhibition. It does not explain this fact, indeed, but it does explain why the disturbing activity needs to follow the lesson very promptly and it is not incompatible with the general interference theory, as that in turn is not inconsistent with the theory of atrophy through disuse. The difficulty in devising a crucial experiment to decide between these theories of retention may be that they are all true and not inconsistent with each other.

Retroactive shock effect. If consolidation is a real process, it might be disturbed by a shock such as a blow on the head.

Instances like the following personal observation have been frequently reported. A young man, while out in the hills with some friends, fell from a tree upon his head, cutting the scalp and being knocked unconscious for a few moments. He soon recovered enough to walk the three miles to his home, conducting himself in a fairly normal manner, though in a sort of daze, from which he gradually emerged after some hours, with no memory of the walk home, nor of the fall from the tree, nor of a period of some fifteen minutes *before* the fall. The shock effect, then, was retroactive; it caused an amnesia (loss of memory) for events that happened just before the shock, as if it checked a process of consolidation. The amnesia for what happens during high fever, or during intoxication, may similarly be due to abnormal brain conditions preventing consolidation.

Perseveration. If you have been busy with certain material, it may "bob into your head" at odd moments a little later. A tune may persist in "running in your head" when you wish it would stop. Scenes from the day's experience may flash before your "mind's eye" as you lie in bed before going to sleep. Important news, submerged during strenuous mental work, emerges as soon as there is a moment of relaxation. A recent activity that thus reasserts itself, without any apparent cue or stimulus to arouse it, is said to "perseverate." Some persons are much more subject to this perseveration than others.

The tendency of interrupted activities to perseverate. If you are prevented from completing an activity in which you have got well started and absorbed, this activity is especially likely to show perseveration. Such, at least, is the indication of a memory experiment which dealt with the question in a novel way (*23*). The experimenter gave the subject a series of little tasks, each of which required a few minutes to complete. Specimen tasks were: to write down from memory a favorite poem, to model a dog in clay, to draw a vase with flowers according to the subject's taste, to multiply two four-place numbers, to solve a riddle. About twenty tasks were given but half of them were interrupted by the experimenter

removing the materials and saying, "That is enough for that, now turn to this other task." As soon as the series had been gone through, the subject was asked to name all the tasks, and it was found that about 68 percent of the interrupted tasks were recalled, and only 43 percent of the completed. The interrupted ones seemed to be left in a condition of readiness for renewed activity.

All in all, though the evidence for a consolidating process following active learning is scrappy and inconclusive, we have to reckon with the probability that a vivid experience, an intense activity, is likely to persist in some form for a few minutes at least. During this time, we may well believe, it deepens its memory trace in the brain structure.

How to avoid forgetting. The learning process, as we saw, is susceptible to good (or poor) management. Retention, though an inactive state, can be intelligently managed to some extent. The first principle is that material must be "overlearned" in order to be long retained, i.e., it must be learned beyond the point when it can barely be reproduced. The best way of overlearning is to review the material after an interval. Experiment shows that material relearned after partial forgetting is better retained thereafter, and that repeated reviews at rather long intervals fix the material very durably.

The value for retention of a short period of relaxation after learning is suggested by several of the experiments we have considered.

The rules for economy of memorizing hold good also for retention. Forgetting is slower when relationships and connections have been found in the material than when the learning has been by rote. Forgetting is slower after active recitation than when a more passive method of study has been employed. Forgetting is slower after spaced than after unspaced study, and slower after whole learning than after part learning.

An old saying has it that quick learning means quick forgetting, and that quick learners are quick forgetters. Experiment does not wholly bear this out. A learner who learns

quickly because he is on the alert for significant facts and connections retains better than a learner who is slow from lack of such alertness. The wider awake the learner, the quicker will be his learning and the slower his subsequent forgetting.

How to forget. The obvious answer, from what precedes, is, "Don't review." But is there anything more that one can do? Is there such a thing as "active forgetting"? There are painful experiences that we should like to erase from memory, especially experiences that hurt our pride and self-respect, and if psychology could show us any way of killing these memories, we should like to use it. Some persons have a way of violently *repressing* such memories, and producing a genuine amnesia for them. It is a recall amnesia rather than a retention amnesia; the repressed material, though inaccessible most of the time, may reappear under hypnosis or psychoanalysis, or in dreams or daydreams, or in a sort of trance or hysterical attack which these persons are liable to have from time to time. The process of repression is not well understood, and psychology cannot tell the anxious inquirer exactly how to go about it. But this much is clear, that it is an unmanageable process which carries into the discard more than the subject means to lose. It carries away useful material that is associated with the painful experience; it may involve loss of appetite, or loss of the use of a hand or of the eyes, just because these activities are tied up with the experience which is violently thrust out of memory. So this type of active forgetting is not to be recommended for general use. If involved in something we shall hate to remember, the best rule is to face the facts, think them through, do what needs to be done, and reach a satisfactory adjustment before laying the matter aside. By completing the job now we avoid the necessity of reopening the troublesome matter later.

RECALL

Learning does not guarantee later remembering, for retention may fall too low to permit of recall. Even good reten-

tion does not guarantee recall. We know a person's name, as is proved by our recalling it later, but at the moment we cannot get it. We know the answer to an examination question, but in the hurry and worry of the examination we give the wrong answer, and only later does the right answer come up. Some sort of interference blocks recall in such cases.

Interference in recall. One type of interference is emotional. Fear may paralyze recall. Anxious self-consciousness, or stage fright, has prevented the recall of many a well-learned speech, and disturbed many a well-practiced act. Another type of interference occurs when two acts are both aroused at the same time, and get in each other's way. You will sometimes hear a speaker hesitate and stumble because two ways of expressing his thought occur to him at the same instant. One recall blocks the other. Something of the same sort often happens when you start to recall a person's name. You get some other name which is more readily aroused at the moment, and, thus put off the track, labor in vain to reach the right name. Drop the matter, and a little later the desired name is recalled without trouble, because the interfering activity has quieted down and lost its temporary advantage. This plan of dropping the matter when one is confused, and taking it up again when fresh, works well in other cases besides hunting for a name.

Partial recall. Imperfect recall is likely to be distorted rather than merely fragmentary. For example, a name eludes us; we have it vaguely but it will not take definite shape. However, something does take definite shape, some complete name emerges, only it is not the name we want. In the list of cases below, contributed by several individuals, each line contains the name first recalled, followed by the true name that was sought.

Manning–Mayo
Bogert–Burgess
Macdonald–McDougall
Hennessy–Haggerty
Stoop–Cole
Ernst–Stern

Barclay–Clayton
Adleman–Wadleton
Balboa–Bonivard
Sonnenschein–Sonneborn
Kohlrausch–Rauber-Kopsch
Underwood–Overstreet
Poseidon–Parmenides
O'Rourke–McCrea
Guy Lussac–Ives Delage

Examination of these and many other samples shows that the erroneous name recalled commonly preserves the general character of the true name—the language or nationality, the number of syllables and accent, and the initial sound. In these cases of hampered recall, one seems to start towards the goal but to stray into a blind alley.

A still better experiment on partial recall is one with nonsense drawings, shown for a moment and reproduced later from memory (see p. 352). The general shape of the drawing is more apt to be reproduced than the details. A drawing seen to resemble any familiar object is modified in recall into a better representation of the object. Details which originally made little impression on the observer drop out, leaving the figure more compact and simple. Much the same is certainly true of the recall of events and experiences: the impressive facts remain, less impressive facts disappear, and the whole story is rounded out. When any emotional bias adds its distortion, the resulting memory may be very wide of the original events. The memory trace in many cases has become too vague to give a complete story or picture, and what we get is more a new construction than a genuine reproduction (*2*, *9*).

Recall of childhood experiences. Most experiences of early childhood are forgotten before adult years, to judge from the meager result of casually trying to recall them. The farther back you go, the fewer incidents you can recall. From all the vivid experience of very early childhood scarcely anything can be recovered.

However, if you assemble all available aids to memory—

pictures and objects connected with your childhood and incidents reported by your parents and friends—and immerse yourself in this material, you may be surprised at the revival of long-lost impressions and incidents, though after all it is

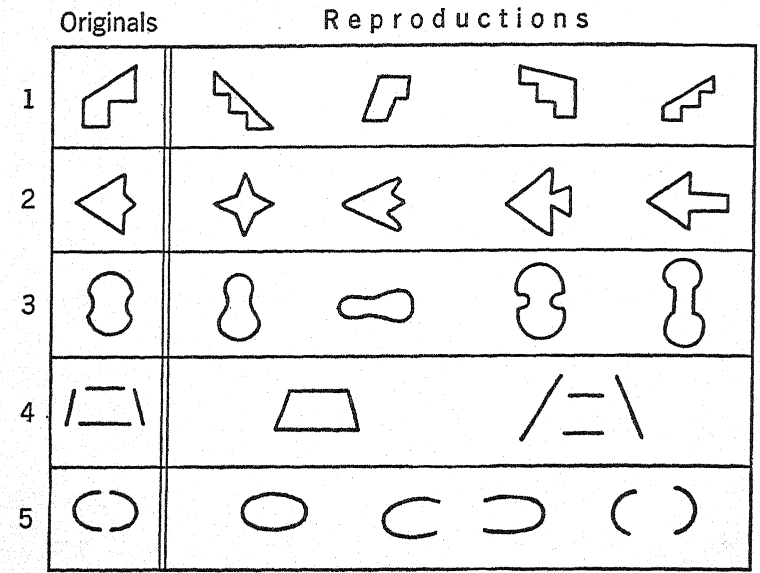

Fig. 65.—(Gibson, 8.) Attempted reproduction of nonsense figures from memory. The subjects were working under pressure, having a series of 14 nonsense figures to memorize. The first figure usually suggested stairs, but reminded one subject of a ship's ventilator. The second figure was seen by different subjects as a star, a bird, an arrowhead, and an arrow. The third was seen as a woman's torso, a footprint, a violin, a dumbbell. In reproducing the broken figures the subjects tended either to close the gaps or else to exaggerate them.

a meager harvest compared with the wealth of early experience which you do not recover.

Several special devices have been employed for assisting the subject to revive early memories, all of them aiming to put him into a relaxed and half-dreamy state. Hypnosis is one such device; another is crystal gazing (staring abstractedly into a glass ball), and still another is automatic writing, which consists in letting the hand write without conscious control or attention to what is being written. You ask your subject questions bearing on his childhood, and he replies in

automatic writing, or sees pictures in the crystal; and, though he may not recognize the incidents thus brought to light as his own experiences, testimony from parents may verify them. Such probing has been attempted in the hope that revival of early memories would afford the means for correcting abnormal fears or other unfortunate twists in the personality dating from early childhood; but the results are only moderately encouraging (*11, 15*).

Memory images. If a recalled fact or experience comes back with a decided sensory character—if it is realistic and like actual seeing or hearing or smelling, it is called a memory image. Can you recall the blue of the sky, or the tone of the violin or of a friend's voice, or the odor of camphor, or the feel of a lump of ice in the hand, or the way it feels to jump, or kick, or yawn, or clench your fist? Almost everyone will answer "Yes" to some or all of these questions. One will report getting a vivid picture of a scene, and another a realistic mental rehearsal of a piece of music. What they recall seems to them essentially the same as an actual sensory experience.

Individuals seem to differ greatly in the vividness or realism of their memory images as was brought out in an earlier chapter (p. 65). Some psychologists, who prefer to admit only strictly objective data into the science, deny the existence of memory images, or seek to explain them away as combinations of present sensory experience and motor response; but these theories do not ring true, and the fact certainly seems to be that sensory experience as well as motor activities can be revived or recalled.

Most memory images, indeed, are inferior in realism and completeness to actual sensory experience. From the practical standpoint they are inferior in that facts cannot be found in the image of a thing unless they were observed in the actual presence of the thing.

At one of the universities, there is a beautiful library building with a row of fine pillars across the front, and the students pass this building every day and enjoy looking at it. A favorite experiment in the psychology classes at that uni-

versity consists in first asking the students to call up an image of the front of the library, and then asking them to count the pillars from their image. But at this point the students begin to object. "We have never counted those pillars, and cannot be expected to know the number now." In fact, few of them give the correct number, and those whose images are vivid and realistic are little better off in this respect than those whose images are dim and vague.

Ordinarily, in looking at a beautiful building, we simply take in the general effect; and when we later get an image, it is just this general effect which we recall. If we pick out details, we can later recall them. If we study the color scheme, or the balance of masses, while looking at the building, we can recall what we have observed and no more.

The primary memory image—eidetic images. What has been said of images, so far, refers to those recalled some time after the original experience. The primary memory image is different in that the experience is simply persisting (or perseverating) for a few moments after the original stimulus has ceased. For a few seconds after somebody has stopped talking, you can still hear his voice, as if in an echo. You may be able to recover what he has said, though you were not closely attending to it at the instant when he was speaking. In the same way, immediately after you have looked over the landscape out of your window, you can still see it better than you can recall it later. This primary memory image is not the same as the "after-image" mentioned in the first chapter (p. 15).

Now it appears that many children under fourteen years of age, perhaps half of them, if they examine any complex object or picture in an absorbed way for half a minute, and then shut their eyes, or, still better, turn them upon a plain gray background, can *see* the object as if it were still before them, and can answer questions about it which they did not have in mind during the actual presence of the object. This image is not strictly photographic, but rather plastic, and likely to be modified by the subject's interest. The object may grow larger, or may become more regular, or may ap-

pear to move. The color may become more brilliant, or may change to a different color. Such changes may be either voluntary or involuntary. This type of image, then, is quite subjective, though on the whole it conforms rather closely to the scene from which it was taken.

These peculiarly vivid and detailed primary memory images have been called "eidetic images," and the individuals who have them "eidetic individuals." Eidetic imagery seems to be most common in later childhood, and to fade out, usually, during adolescence, though a few adults can still obtain images of this sort. Such images, though usually appearing, if at all, immediately after being immersed in the actual contemplation of an object, may reappear later (*1, 10, 14, 16*).

Hallucinations. Since a vivid memory image may be "in all respects the same as an actual sensation," according to the testimony of some persons, the question arises how such an image is distinguished from a sensation. Well, the image does not usually fit into the objective situation present to the senses. But if it does fit, or if the objective situation is lost track of, then, as a matter of fact, the image may be taken for an actual sensation.

You are half asleep, almost lost to the world, and some scene comes so vividly before you as to seem real till you awaken to the reality of your surroundings. Or you are fully asleep, and then the images that come in your dreams seem entirely real, since contact with the objective situation has been lost.

Images taken for real things are common in some forms of mental disorder. Here the subject's hold on objective reality is loosened by his absorption in his own fears and desires, and he hears reviling voices, smells suspicious odors, or sees visions that are in line with his fears and desires.

Such false sensations are hallucinations. A hallucination is a memory image taken for a sensation; it is something recalled or built up out of past experience and taken for a present objective fact.

Synesthesia. A considerable number of normal persons have the peculiarity of hearing what seem like colored sounds,

a deep tone sounding dark blue, it may be, a trumpet bright red. Each vowel and consonant may have its own special color, and a word may have a color scheme built up out of the colors of the letters. Numbers also are likely to have their colors. Colored hearing is the commonest, though not the only form of synesthesia, which consists in responding to a stimulus acting on one sense by sensations or images belonging to another sense. The synesthesia probably originated in childhood from playfully linking the different kinds of sensation together.

Management of recall. No very definite rules can be given. One good general principle, applicable to the taking of examinations or the making of a speech, is to avoid the interference of self-consciousness and worry, by forgetting about yourself and becoming thoroughly immersed in the matter in hand. When balked in the attempt to recall a name or fact it is well to have one good try and then let the matter rest for a few minutes, giving your attention to something else. Often the item will then come back spontaneously. In reviving the memory of some incident take plenty of time and let your mind play all around the matter, approaching it from various sides. If called upon to give important testimony regarding an incident, it is no more than fair to be critical of your own memory, realizing that the traces are probably not definite and complete enough to give back all the facts, and that you will be constructing a story that seems probable rather than reproducing the original incident.

RECOGNITION

The experience of recognizing. In our preliminary definitions recognition was said to consist "in knowing an object that has been experienced, in being acquainted with an object now because you previously became acquainted with it." Recognition is more readily defined as an experience than as a kind of behavior. The experience expressed in such words as "I remember that man," "I know that piece of music," or "I recognize this place" is well known to every

adult and older child. We express ourselves in this way when we are somewhat startled at seeing a familiar object where we did not expect it. We are not likely to exclaim on entering our room at the close of the ordinary day, "I recognize this place!" We do recognize it, however, in the sense that we know it and feel acquainted with it. Familiar objects in their familiar settings we recognize so quickly and easily that the experience can scarcely be analyzed.

Sometimes recognition is slow and attended by curious feelings. You see someone who looks familiar, and feel that you must have seen him before. This *feeling of familiarity* haunts you till you can remember more about him, and may be much more than mere familiarity, as if you had seen him recently, or a long time ago, or as if you had been amused by him, looked up to him, been on your guard against him, or bought something of him. Such impressions often turn out to be correct. The attitudes of amusement, deference, hostility, etc., were originally aroused by the individual as he conducted himself in a certain setting. When you later see the person apart from all the rest of the original situation, some of your original response is awakened. To judge from such cases, the response in recognition may be the revival of any attitude formerly aroused by the object now recognized; and the stimulus to recognition may be a mere fragment of the situation which originally aroused this response.

Abnormal feelings of familiarity and strangeness. When one is in a let-down state, and far from alert and keen, even a decidedly novel situation or happening may arouse a feeling of familiarity, a weird feeling that one has been through all this before, as if time had slipped a cog and were now repeating itself. Perhaps 50 percent of young people can remember having had this queer experience, and some few individuals suffer from it a great deal. It may be called the "illusion of having been there before."

The opposite illusion, called the "feeling of strangeness," also occurs in some abnormal conditions. The subject uses familiar articles well enough, and knows the names of his

family and friends, but he insists that people, places and objects all seem new and strange to him, and naturally he is much disturbed. A full explanation of these illusions of recognition is not known.

Behavior in recognition. We unhesitatingly say of another person, even of a little child, that he recognizes an object, if his present behavior toward the object has evidently been learned in past dealings with that object. The baby smiles at a person who has pleased him before, shrinks from one who has displeased him, and thus shows recognition of both. His smile was first attached to a certain person when that person was doing something to please him. Later the baby shows recognition by smiling as soon as he sees the person without waiting for anything amusing to happen. The smile reveals a learned adjustment to the person. The smile becomes reduced as the baby grows up, and the adult has a mere feeling of amusement on encountering a person who has previously amused him, and so recognizes that person without the necessity of openly grinning to his face. The adult can recognize an object without expressing himself in any visible or audible manner, but his previously learned adjustment to the object is revived and gives him the feeling of familiarity. The feeling might be called shorthand behavior.

Behaviorally, recognition is not limited to human beings but must be a primitive and fundamental sort of memory. When placed in a strange maze, the rat explores and in a few trials learns that maze so as to traverse it unerringly from entrance to food box. If he is replaced in the same maze after a few days of rest, he first does a little exploring near the entrance and then starts full tilt for the food box. That is clearly recognitive behavior. We cannot say what the rat feels, but his previously learned adjustment to that maze is certainly revived.

Recall and recognition. Recognition seems to be the simpler of the two processes. After studying a list of names you can recall some of them, but you recognize more than you recall. After examining a nonsense drawing you may reproduce it very imperfectly and still recognize it with confi-

dence when it is shown again. Recall is a bigger job than recognition, for in recall you must get back the material previously studied, while in recognition the material is given and you have only to reinstate your former acquaintance or adjustment. However there are degrees of recognition. On seeing a person you may recognize him to the extent of feeling sure you have seen him somewhere, without being able to "place" him. In order to recognize him to the fullest extent you have to *recall* when and where you made his acquaintance.

Direct and indirect recognition. Odors have been used in experiments on recognition, just because they are not, as a rule, so easily and quickly recognized as are objects seen or heard. A theory to be tested in these experiments held that recognition was accomplished by the recall of the original setting of the odor in some past experience. A certain odor might recall to mind a mountain-side, and so lead to its recognition as the odor of a mountain flower. This indirect type of recognition does occur, but is less common than the direct sort, in which the odor is known before recall of the past experience has time to take place. Therefore, the theory mentioned cannot be accepted as a general description of the process of recognition (*6*).

Errors of recognition. Recognition is not infallible by any means. If an object now presented *resembles* one seen before, there may be false recognition. In one experiment, pictures are shown one after another, and later shuffled together with other pictures, some of which are quite similar to those shown, while others are very different; the whole mixed lot is now presented, one picture at a time, and the subject is to say "Yes" to those he recognizes and "No" to those that seem new. He says "Yes" to many that are only similar to those he saw before, and even to a few that are very different from any he saw before, but these false recognitions are slow and lacking in confidence. He also makes errors of the reverse kind, by failing to recognize pictures that were actually shown him before, and this sort of false response also is slow and doubtful, on the whole. The correct recognitions, on

the other hand, are usually quick and confident. But the quickest and surest responses of all are the "No" responses to the new pictures. Non-recognition, then, or the knowing of a thing to be new, is not a mere absence of recognition, but is a quick, definite, emphatic action (*19*).

Management of recognition. As suggested by the results in the preceding paragraph, you cannot be sure of subsequently recognizing an object now present unless you observe it carefully and notice how it differs from other similar objects. Ordinary casual observation of faces is not enough to insure correct recognition later. Testimony experiments have shown that one may confidently identify a person and still be in error; and cases have occurred in the courts in which an individual has been convicted and sentenced to prison for a long term of years, though later developments prove that this individual had no connection with the crime. Such cases of mistaken identity warn us to be critical of our own memories in respect to recognition as well as recall. You can learn to draw a line between recognition that is perfectly confident and recognition that is attended with some feeling of doubt. In trying to recall a name you may get one that seems pretty good and yet not surely right. You do not confidently recognize the name that you have recalled. Very likely it is not the right name. By checking on yourself you may learn how much importance to attach in your own case to these feelings of sure and doubtful recognition.

MEMORY TRAINING

The important question whether memory can be improved by training breaks up, in the light of our division of the subject, into the four questions: whether memorizing can be improved, whether the power of retention can be improved, whether recall can be improved, and whether recognition can be improved. Some suggestions have been made in earlier paragraphs, looking toward good management of each of these parts of the total memory function. Recall and recognition, being active processes, can be controlled and practiced

to some extent, but they are rather elusive and so far there are only a few points of technique and good management to offer. People are most apt to be concerned about their powers of retention, and here there is no chance for direct control. You can make sure of thorough learning, you can relax after study and let the material "soak in," you can review, but you cannot get at the memory trace and it is hard to see how anyone can improve the sheer retentiveness of his brain. About all that can be suggested is to keep the organism, and with it the brain, in good physical condition. Retentiveness can be protected by hygienic measures, but not improved, so far as we know, by any sort of training.

The process of learning or memorizing, however, being a straightforward and controllable activity, is exceedingly susceptible to training. The beginner in learning lists of nonsense syllables is emotionally wrought up and insecure, goes to work in an uncertain way, perhaps tries to learn by mere rote or else attempts to use devices that are ill-adapted to the material, and has a slow and tedious job. With practice in learning this sort of material, he learns some appropriate technique, becomes sure of himself and free from emotional disturbance, and may even enjoy the work. Certainly he improves greatly in speed of memorizing nonsense syllables. If, instead, he practices on Spenser's "Faerie Queene," he improves in that, and may cut down his time for memorizing a stanza of that poem from fifteen minutes to five. This improvement is due to the subject's finding out how to organize this particular sort of material. He gets used to Spenser's style and range of ideas. And so it is with any kind of material; practice brings great improvement in memorizing that particular material.

Transfer of training. Whether practice in memorizing one sort of material brings skill that can be "transferred," or carried over to a second kind of material, is quite another question. Usually the amount of transfer is small compared with the improvement gained in handling the first material, or compared with the improvement that will result from specific practice with the second kind. What skill is transferred

consists partly in the habit of looking for groupings and relationships, and partly in the confidence in one's own ability as a memorizer. It is really worth while taking part in a memory experiment, just to know what you can accomplish after a little practice. Most persons who complain of poor memory will be convinced by such an experiment that their memory is fundamentally sound. But these laboratory exercises do not pretend to develop any general "power of memory," and the much advertised systems of memory training are not justified in any such claim. What is developed, in both cases, is skill in memorizing certain kinds of material so as to pass certain forms of memory test.

What has just been said of the transfer of memorizing skill holds good of other skills as well. In using any given tools and materials, the learner adjusts himself to the specific character of his particular job and is very likely not to discern any general principles that can be carried over to other jobs. Fortunately, however, it has been found that suitable instruction in principles of good management of such work, with a moderate amount of practice devoted to applying the principles, does build up a body of transferable ability (*4*). And the same has been found true of memory training. A moderate amount of practice in memorizing nonsense syllables and poetry, with instruction on the best methods of memorizing, enabled a class of college students to attack other kinds of memory material with unusual success. In the training, emphasis was placed on the value of a confident attitude, alertness and concentration, attention to meaning and grouping, recitation, and learning by wholes rather than in small parts (*22*).

Numerous experiments on transfer prove that it is not safe to trust to any automatic spread of ability from one activity to another. What is successfully transferred is usually something you can put your finger on—a principle, a good emotional attitude, a technique.

When anyone complains of a "poor memory" for any special material—names, errands, engagements—the trouble can usually be found in his heedless way of committing the

facts to memory, not in his power of retention. President Seelye of Amherst College, back in the '80s, never failed to call a student or alumnus by name, after he had interviewed the man in the freshman year. In this interview, besides fatherly advice, he asked the man personal questions and studied him intently. He was interested in the man, he formed a clear impression of his personality, and to that personality he carefully attached the name. Undoubtedly this able scholar was possessed of an unusually retentive memory; but his remarkable memory for names—a definite social asset —depended largely on his technique.

Contrast with this the casual procedure of many of us on being introduced to a person. Perhaps we scarcely notice the name, and make no effort to attach the name to the personality. To have a good memory for names, one needs to give attention and practice to this specific matter. It is the same with memory for errands; it can be specifically trained. Perhaps the best general hint here is to associate the errand beforehand in your mind with the place where you should remember to do the errand.

Often some little *mnemonic system* will help in remembering disconnected facts, but such devices have only a limited field of application and do not in the least improve the general power of memory. Some speakers, in planning out a speech, locate each successive "point" in a corner of the hall, or in a room of their own house; and when they have finished one point, look into the next corner, or think of the next room, and find the following point there. It would seem that a well-constructed speech should supply its own logical cues so that artificial aids would be superfluous. In training the memory for the significant facts of one's business, the best rule is to interrelate the facts into a system.

In general, memory training consists in improved management of the learning process. Observant study, alive to patterns, relationships, meanings, and promising cues for later recall—economy of effort in learning, by use of recitation, spacing, and the best combination of whole and part study to fit the material in hand—these principles of good manage-

ment indicate the field in which memory can be effectively trained.

Summary of the chapter. Memorizing, or learning, is an active process of organizing the material to be learned by use of unifying characteristics observed in the material or imposed on it by the learner. Repetition is necessary and "overlearned" material is better retained than material which is merely organized. Active recitation, reviewing at intervals, and learning the details as parts of the whole economize time in memorizing and favor good retention. The cause of forgetting may lie partly in the interference of new activities with the memory trace of what has been learned, and partly in the biological factor of atrophy through disuse. Material that is still retained may require relearning to brush it up, and may not be readily recalled because of interfering factors. The "reproduction" of a picture or story is really a new production making use of the memory trace and of other guides and biases. Recognition consists in the reinstatement of an attitude or adjustment originally aroused by the presence of an object. Practice in memorizing a specific kind of material—like the stanzas of a certain poet—greatly improves the ability to memorize this material but does not improve general memory unless principles of good technique and management are acquired along with the specific skill. The same is true in other instances of attempted "transfer" of ability.

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Chapter XI

Motivation

A MAN'S achievement may fall far short of his ability. The college teacher will easily think of examples from among his students, and it is almost equally true in athletics or dramatics that some individuals who seem to have plenty of ability are very disappointing in actual performance. Sometimes their ability is overrated, but quite often their mediocre performance is due to lack of effort or to a scattering of effort. They may be indifferent, they may dislike an activity or the persons connected with it, they may be "dissipating," or they may have undertaken more activities than they can carry. In all such cases the individual is said to lack adequate motivation.

We may say that achievement = ability × motivation. Unless both factors are large we cannot expect any outstanding product.

In testing for any ability it is obviously necessary to secure good motivation. A young child may be timid or negativistic on first being tested and come out with an IQ very much lower than he gets a few weeks later when he has become adjusted to the nursery school. An older subject, while eager to do his best, may be worried and self-conscious and fail to do himself justice. These examples show that poor achievement is due, at times, not so much to weak motivation as to a conflict of motives.

Motivation is fully as important in adult activities as in the period of growth and preparation for life. It is important in friendship and family life as well as in business and public

affairs. Our purpose in this chapter is to ask how the individual can be motivated to high or at least satisfactory achievement in any line. As usual, no list of hard and fast rules will be offered, but the attempt will be made to reach such an understanding of motives and their operation as will provide a good background for anyone who wishes to secure action from other people or from himself.

Definitions. Though familiar words are employed in speaking of problems of motivation, the psychologist gives them precise meanings and distinguishes them more sharply than is done in ordinary usage. *Motive* and *incentive* are to be distinguished, since a motive is in the individual, an incentive outside. An incentive is a goal-object, something that appeals to a motive. In a prize contest, the prize is the incentive, while the motive may be a need for money or a liking for contests and especially for winning. For one individual the prize is an incentive because of its money value, for another because it is a public symbol of victory in a contest.

Motive does *not* mean the same as *stimulus.* A stimulus elicits a particular response. In working on a prize contest, one is making many responses to stimuli received from the material—crossword puzzle or whatever it may be. A stimulus always comes out of the momentary situation, while a motive is present in the individual before the stimulus arrives. The same motive may underlie a long series of particular responses to stimuli. Consider a very simple case. If my hand touches a hot stove and I jerk it away, there is no excuse for saying that my motive is to escape the burning heat. The movement is a direct response to the hot stimulus and no motive was *present in advance* preparing me to make this response. But suppose, while the pain in my hand continues, I see a pail of water and plunge my hand into it. This is not my usual response to a pail of water, but at this particular moment there is something unusual going on, a seeking to escape from the pain in my hand. This seeking is the motive, while the stimulus is the sight of the pail.

In this straightforward act there is no separation between

stimulus and incentive. If we introduce a slight complication, by supposing that I run into another room to obtain water, we can draw a distinction. The water in the other room is the incentive, while the stimulus at the moment of opening the door is the sight of the door. In going from one room to the other I execute a series of responses to stimuli from the immediate environment, while the motive remains the same for the entire series and binds it together into a single act. Behavior comes in lengths rather than in separate stimulus-response units (p. 31).

Typical examples of motive, incentive and stimulus are afforded by hunger behavior. The *incentive* is food not yet obtained, food as a goal to be reached. The *stimuli* during the search for food come from paths, landmarks and other objects in the environment. During eating the stimuli come from food in the hand or in the mouth. The presence of food arouses the eating movements, provided one is hungry, not otherwise. The *motive* is the state of hunger, or the set for obtaining food, or the food-seeking and food-taking as an activity in progress. Hunger is primarily a chemical state of the organism rather than a goal set or activity in progress, but this organic state gives rise to vigorous stomach contractions (felt as hunger pangs) which excite the organism to restless activity and to a search for food.

A motive, then, is a state or set of the individual which disposes him for certain behavior and for seeking certain goals.

A motive is not a source of energy in any physiological sense. Hunger, when you stop to think, is not a source of energy; rather, it is a *need* for energy, i.e., for the fuel present in food. Hunger is a warning that the fuel bin is getting low. We can say that hunger, or any motive, releases energy and steers it in a certain direction. So considered, a motive is called a *drive*, in allusion to the drive of a machine, the belt or gears by which power is transmitted from the engine to a lathe or other element of a machine shop. Each machine in this analogy represents an ability of

the individual; some motive power must be applied to an ability to put it into action. The individual has the ability to do a certain thing, but will he do it? He must have a motive; the machine must be driven.

To get an adequate analogy from the automobile, we need to include both the accelerator, which releases energy and determines the amount released, and the transmission, which propels the car forward or backward according to the set of the gears. *A motive, or drive, releases some of the organism's store of energy and directs it into a certain channel.*

The word *drive* is preferred by animal psychologists, because it carries no implication of conscious experience or desire. *Motive,* also, should be understood in a very broad sense; some motives may be conscious and others unconscious.

ANIMAL DRIVES

A science of motivation, no less than one of learning, can derive some basic information from animal studies, because conditions are well controlled in the animal laboratory and because of the animal's simplicity and naïveté. The experimenter, like anyone who desires to get action from other individuals, encounters the problem of motivation in a practical form. He asks whether his animal subjects need to be motivated and, if so, what motives are available. He finds that white rats when placed in a strange maze explore it in a leisurely manner; but if they find food somewhere in the maze they display much more energy on the next trial. If they are to learn the shortest path from the entrance to the food box they must be motivated. They are taken when hungry and rewarded with food, or taken when thirsty and rewarded with water, etc. The incentive must match the animal's organic state.

Measurement of drives. In one type of experiment, energy output is measured by use of the *activity cage,* which is like a squirrel cage in being provided with a vertical wheel for the animal to run in when so disposed. A mechanical

counter shows the number of times the animal's running has turned the wheel around. While hungry the animal runs a good deal but after a meal very little, as we should expect. An animal deprived of certain endocrine glands—pituitary, thyroid, gonads, adrenal cortex—is very inactive.

The *obstruction method* offers the animal a reward or in-

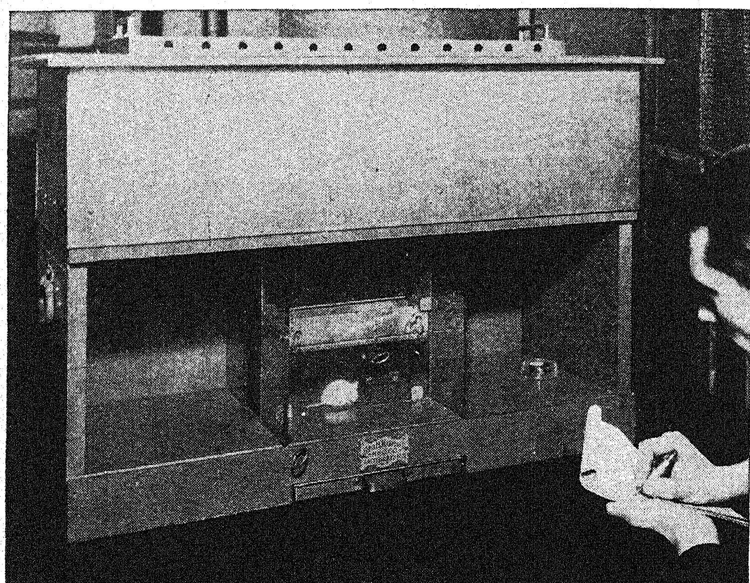

FIG. 66.—(Courtesy of C. J. Warden.) An obstruction box. The starting compartment is at the left. The rat is shown on the grid, advancing toward the food compartment at the right.

centive but places an obstruction in the way to the goal. A convenient obstruction consists of an electrified grill in the floor of a tunnel through which the animal must pass in order to reach the incentive. The shocks are strong enough to make the animal avoid the tunnel unless there is some incentive present on the far side. After crossing the animal is allowed only a little nibble of food, or a correspondingly small portion of whatever reward is offered, and then is placed back at the entrance. He is given a total of twenty minutes, and the question is how many times he will cross the grill to the incentive.

With white rats as subjects, there are about 3 or 4 crossings in twenty minutes with no particular incentive. When the rats are hungry and food is the incentive, the number of crossings is about 18 on the average after a fast of 2-4 days, but after still longer periods of fasting the number of crossings declines. We may accept 18 crossings in the twenty-minute test period, then, as the maximum effect of the hunger drive (for the average white rat of a certain age). In the same way the maximum is determined for thirst and for other drives. The strength of the maternal drive is tested by taking a mother rat from her litter and making it necessary for

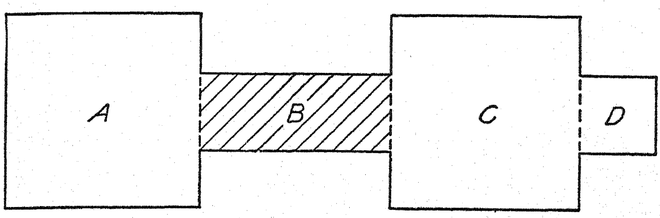

FIG. 67.—(Warden, *13*.) Ground plan of an obstruction box. The animal is placed in compartment *A* and the incentive in *C* or *D*. To reach the incentive the animal must cross through the narrow, low passage *B* and take electric shocks from the wires in the floor.

her to cross the grid in order to reach the young. She makes a higher score within a few hours after childbirth than a week later; in this species, then, the maternal drive declines rather rapidly. The sex drive is tested by placing a mate beyond the grill. During the active period of the estrous cycle (p. 176) the female rat will cross the grid repeatedly to reach the male, but during the inactive period she will scarcely cross at all. (During the active phase she also makes an extremely high score in the activity cage.) The male rat, similarly tested, shows no cycle but crosses the grid much less after a period of free sex activity than after 24 hours or more of sex deprivation.

In estimating the comparative strength of these various drives, we should take each one at its maximum. The results, expressed in numbers of crossings of the grill within the twenty-minute test period, are as follows (*13*).

Drive Tested	*Average No. Crossings*
Maternal	22.4
Thirst	20.4
Hunger	18.2
Sex	13.8
Exploratory	6.0
No incentive	3.5

Small differences in these averages are not well established, but there seems no doubt that the maternal, thirst and hunger drives, at their respective maxima, are more insistent than the sex drive at its maximum, and that the sex drive in turn is stronger than the exploratory. With regard to the last point,

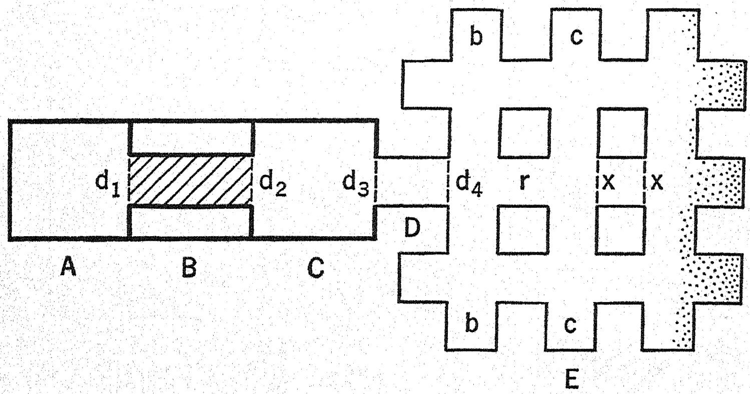

Fig. 68.—(Nissen, in Warden, *13*.) The obstruction box arranged to test the exploratory drive. The animal, placed in *A*, must traverse the passage *B* and step on the electrified grid in order to reach *C* and the enclosure *E* which contains sawdust and other objects such as rats are wont to investigate.

however, the animal psychologists report that the rat foregoes either food or sex activity in any strange locality until he has first explored the place. There seems no possible doubt of the genuineness of the exploratory tendency, at least in the white rat.

There is good evidence also of an activity drive, a drive for motor activity. A rat in the activity cage spends a good share of the time running in the wheel, instead of sitting still

in the rather contracted stationary part of the cage, and the counter attached to the wheel often records the equivalent of 5, 10 or even 20 miles in the course of twenty-four hours (*10*).

If we admit an activity drive, we must certainly add the rest and sleep drive, and in this case we need have no hesitation in extending the conclusion to the human species.

UNLEARNED MOTIVES—FORMERLY CALLED INSTINCTS

In the study of human or animal motivation, it is important to consider the effects of experience and to ask whether any motives result from maturation and do not depend on learning. Some of the animal drives can scarcely have been acquired by learning. We cannot conceive that the animal learns to be hungry or thirsty, or that the female picks up the estrous cycle by learning from older females. There is excellent evidence, also, that the maternal behavior of the female rat is largely "instinctive" rather than learned (p. 176). The activity and exploration drives could conceivably have been derived from a more primitive tendency to move about when hungry or thirsty. In the course of such restless movements the young animal would come across food or water and these "rewards" would reinforce the restless tendency and give it more point.

It is more likely, however, that both muscular activity and activity of the sense organs are entirely primitive and unlearned. Active playful behavior occurs in the young animal or child when it is not hungry or thirsty. It seems to be natural for a young creature, when well rested and in good condition, to engage in activity, both muscular and sensory. We may reasonably assume an unlearned tendency to move about, look, listen, touch, sniff and taste—in short an unlearned exploring drive.

We can go a step farther in view of our fundamental principle (p. 23) that the organism is equipped by nature to *deal with the environment.* Being so equipped, the organism

finds it easy to deal with the environment in a crude, primitive way at least. The exploring drive, accordingly, is more than a readiness to engage in muscular and sensory activity. It is a readiness to get acquainted with the environment. In so doing the animal immediately begins to learn, and its behavior in the environment becomes in large measure learned behavior. But its orientation toward the environment is fundamentally unlearned.

To some thinkers on these matters it appears self-evident that dealing with the environment occurs only in the service of the organic needs for food, etc. They say that the muscles and sense organs have evolved simply as tools for the better securing of food and other organic necessities, and for reproducing the race. Only the organic needs, on this view, are entitled to rank as primary drives; all activity dealing with the environment is secondary. The facts of evolution do not compel us to adopt this view, for motility and responsiveness to the environment are present way down to the bottom of the scale of animal life. There is no more reason for saying that the muscles exist for the purpose of obtaining food than for saying that food is needed to supply energy for the muscles. (Remember the fable of the belly and the members.) What we find in the young animal is activity directed toward the environment, along with the organic needs, and with no sign that one is more primitive and unlearned than the other. It is safe to assume dealing with the environment as a primitive characteristic of the organism.

Criteria of an unlearned motive. Though it would be desirable to identify certain motives as learned, and others as acquired by each individual from his particular experience in life, it is not easy to do so. Several criteria or indicators of an unlearned motive have been suggested.

1. Universality. A motive common to all individuals of a given species could not, it would seem, be laid at the door of experience, since experience varies so much from one individual to another. Especially when a drive, such as those of hunger and sex, is common to many or all species, would the

assumption be untenable that each individual acquires the drive by learning from his own experience. This criterion of universality, while possessing some merit, cannot be followed blindly, partly because individuals differ in the strength of any drive. Some babies have little spontaneous craving for food, and some adults, whether animals or men, manifest no interest in the other sex. These exceptions have to be explained away, as they usually can be in terms of hormones or other physiological conditions. But the fact of individual differences, due sometimes to hereditary and sometimes to environmental causes, makes it necessary to use caution in employing the criterion of universality.

Another difficulty with this criterion arises from the fact that in certain respects all the members of the same nation or culture group are exposed to the same environmental influences. If the people of one nation talk rapidly and vivaciously, while those of another nation are habitually calm and deliberate in their manner of speech, we cannot conclude that the activity drive is naturally stronger in one nation than in the other, for each generation as it comes along picks up the language and mode of speaking of its elders. The same is true of the folkways and moral code of each group. When we wish to make sure of the universality of any drive throughout the human species, we must not rest content with a sample of our own group; we must, with the anthropologists, extend our survey to cultures very different from our own.

2. *Presence from birth.* Behavior that appears promptly at birth, like breathing, cannot have been learned—or so it is usually safe to assume. This is a fairly good positive criterion but a poor negative one, since behavior that makes its appearance even as late as puberty may depend on continued maturation as well as on learning.

3. *Permanent trend of a changing activity.* Superficially regarded, the eating behavior of an adult is distinctly a learned performance, since both his taste in foods and his table manners are different from those of the little child. Yet the trend of the activity remains the same. It is a trend from

hunger to repletion. Since this trend has not been learned, we may properly speak of the motive in eating, the hunger drive, as an unlearned motive. When any activity, though modified in details by learning and environmental influences, still keeps its primitive trend, we may assume a permanent unlearned motive.

Instinct. Unlearned trends were formerly called instincts, but the use of this particular term led to confusion, because an instinct was (and is) defined as an unlearned activity. In various forms of animals, especially in insects, beautiful examples can be found of complex action patterns which are not learned by the individual. The female wasp of a given species constructs a certain type of nest in which to lay an egg, and this specific type of nest is handed down from generation to generation. But it is not transmitted by teaching and learning, for each generation dies before the succeeding generation is hatched from the egg. In man, however, few action patterns occur that are comparable to the typical instincts in being both complex and unlearned.

If we use the word, "instinct," in speaking of human activities, we immediately become involved in controversies which are mainly disputes over words. We probably contrast instinct with habit, using the former for an unlearned activity, and the latter for a learned activity. But then, since every activity is partly unlearned and partly learned, we can draw no sharp line between instinct and habit, and are always quarreling over the appropriate name for a given activity, though there is no question as to the facts. If we call eating an instinct, someone objects that we are overlooking all the learning that occurs in ways of preparing food and putting it into the mouth, and all the social customs that have grown up around eating. But if we call eating a habit, we are accused of taking the absurd position that man eats only by force of habit and not because he is hungry and has the unlearned trend for satisfying this organic need. If we speak of the sex instinct, someone is sure to carry away the impression that romance, courtship and marriage, as practiced among men, are unlearned activities on a par with the nest-

building of wasps; but if we speak of sex behavior as a habit, we convey the impression that the attraction of one sex for the other is a mere matter of social convention. On the whole, we shall save trouble by minimizing the use of both terms, instinct and habit, and leaving both to be terms of popular rather than of scientific use.

But no such confusion need arise from speaking of the unlearned trend of certain activities, or from speaking of unlearned motives in this sense. The genetic study of motives will have to be much farther advanced than at present, however, before a complete list of unlearned motives can be laid down.

Organic needs. Each need is primarily a chemical or physical condition of the organism. *Hunger* is a depletion of the food materials within the body, *thirst* a depletion of water. *Fatigue* is an accumulation of the waste products of muscular activity, and *drowsiness* or sleep-hunger may be akin to fatigue.

Each of these organic needs motivates a whole system of learned activities. We may speak of hunger behavior, thirst behavior, breathing behavior, rest behavior, sleep behavior, as systems of activity developed from these several trends. In the social life of man, these systems of activity become very extensive. Think of all the activities connected with food: hunting, agriculture, cooking, eating places, table manners, social festivities, the science of nutrition.

The sex motive. Mention has already been made of the basic biological facts: the sex hormones; the estrous cycle in the female animal, with the resulting periodicity of the sex drive; and the gradual recovery of the sex drive in the male after satiation. There is thus revealed an unlearned organic basis for sex activity. In the rat the overt mating behavior also is found to be unlearned (*11*). In man, the organic factors are much the same as in animals, so that there is undoubtedly an unlearned trend in sex behavior. Human courtship must be largely learned behavior, it differs so widely from one social group to another; and yet there is a subtle difference between the young man and the young

woman, in their behavior towards each other, which runs through all cultures and contributes to the attractiveness of each sex for the other.

The maternal motive or mother love. In many kinds of animals, though not by any means in all, one of the parents stays by the young till some degree of maturity is reached. In some fishes, it is the male that cares for the young; in birds it is often both parents. In mammals it is always the mother. A hormone plays a part here, as is seen from the appearance of the mother's milk at the birth of the young. This hormone is present in the human mother, too, and puts her into a special organic state. There is good reason to believe that the hormone has an effect on her feelings and mode of behavior. No doubt the details of child care are learned by the mother, but certain elementary desires do not have to be learned—to cuddle and feed the baby, to seek to stop its crying, to fight off anyone who threatens it.

The escape motive—shrinking from injury—fear. The flexion reflex of the arm or leg, which pulls it away from a pinch, prick or burn, is one of a host of simple avoiding reactions—winking, scratching, coughing, sneezing, clearing the throat, wincing, limping, squirming, changing from an uncomfortable position—most or all of them unlearned reactions. Often a peculiar organic state is present during this trend to escape from pain or injury, the hormone of the adrenal glands being discharged into the blood stream, with the result that the organism is thrown into a keyed-up, excited condition. This condition is sometimes labeled the "emotion of fear," and will be examined more closely in the following chapter.

The little baby fears nothing, or almost nothing. He makes avoiding reactions to stimuli that are directly irritating, but not to stimuli that are simply signs of danger. The fears of older people do not appear in the baby. For example, he is not afraid of a furry animal or of a snake.

If the snake test (a large but harmless snake, carried around by the experimenter, who invites everyone to feel his nice smooth, hard skin) is tried on people of different ages,

no child under two years shows any fear or concern; at three or four they begin to be somewhat wary, and within the next few years some of them show definite avoidance, both boys and girls. College students show more fear than boys and girls of ten or younger (*5*).

How shall the increase of fears with age be explained? Either learning or maturation might conceivably be responsible.

Conditioned fears. It is a very old idea that an individual's special fears and antipathies are the result of early associations, or in other words of early conditioning. To test out this theory an experiment was tried on a healthy boy slightly under a year in age. Albert was accustomed to playing with dogs, rabbits and white rats, but the attempt was now made to condition him against the white rat by associating that pet with a loud rasping noise, produced by striking a long steel bar with a hammer. The white rat was held out to the child, who reached for it. At that instant the bar was struck close behind the child, producing a momentary fright. When this procedure had been repeated a few times, the child not only would no longer play with the rat but actually shrank back at the sight of it. He was then tested with a rabbit and a dog, and showed fear of them, too. The conditioned fear was "transferred" from the rat to similar objects (*14*).

This experiment has been tried on a few other young children with varying results. Some children turn and scowl at the harsh noise and then resume their play with the pet animal. They seem to understand that the noise does not come from the animal and has nothing to do with the animal. Intelligence may protect a child from amassing a lot of needless fears. No doubt, however, many fears are acquired by some form of conditioning. A child may be afraid of dogs because he has been bitten by one. More often he derives this fear from being warned by older people or from observing their fear responses. Children who are originally not a bit afraid of thunder and lightning may pick up a fear of them from adults who betray fear during a storm.

Fears dependent on maturation. Just as development is partly maturation and not entirely learning, so the increase of the child's fears with age is not entirely due to conditioning. Part of the increase is due to the child's growing up. At first he cannot be frightened by way of his eyes, but as he comes to see better, he is startled by sudden movements such as the jump of a frog or of a jack-in-the-box. At first he understands little of what is going on around him, but as he understands more and participates more, he finds more need for caution.

In later childhood, adolescence, and early adult life, many fears are outgrown, overcome, or more or less completely suppressed. The suppression may do away with the external signs of fear without wholly removing the internal organic state. An adult who handles the snake with apparent calm may show beads of perspiration on his forehead; and a person who can stand on the brink of a precipice without panic may yet feel much more at ease when he has retired. Nevertheless, such fears are often really overcome and left behind.

Fighting—anger. Angry behavior as seen in a child of one or two years is a surprising phenomenon. Prevented from doing what he wishes or commanded to do what he does not wish, the child is likely to burst out into undirected motor activity, jumping up and down and screaming; or he may struggle against the interfering person or object; or again he may attack that person or object. This outburst may last for a longer or shorter time, but typically for 1-5 minutes. Such behavior is far from dependable even in the young child and it becomes less frequent as he grows up under civilized conditions (*2*). In anger, as in fear, a large part of the activity is internal and organic, and this part often persists even when the individual has learned to suppress his external pugnacious behavior, or when he has substituted angry talk for the primitive struggling, kicking and screaming.

Pugnacious individuals, dogs or men, seem to derive more solid satisfaction from a good fight than from any other amusement. A good fighting dog will sally forth in search of an opponent. A pugnacious person will "pick a quarrel"

by provoking someone who is minding his own business. We must recognize aggressive fighting, then, as well as defensive, and both sorts are important in social situations.

Exploration. The argument in favor of an unlearned drive for exploring the environment has already been set forth (p. 373). Included under this head are looking, listening and all forms of sensory activity, as well as moving about a strange place. When the baby's eyes follow a moving object, he is exploring, and when he brings every object he gets hold of into his mouth, he is exploring. The trend is from non-acquaintance toward acquaintance with the environment.

There are two main classes of unlearned motives: those serving the internal needs of the organism, and those dealing with the environment. We assume a natural inclination to deal with the environment. From our point of view, exploring is just as basic an activity as eating. It is the first of several drives that are concerned with the things and persons of the environment.

Manipulation. It is characteristic of the human being to explore not only places but objects, and to do so by watching the objects while manipulating them. There must be a natural human propensity for this sort of activity, so early and so spontaneously does it appear in the child's play. As soon as the child can handle external objects, he begins to manipulate them in various ways, which become more complex and efficient as his powers increase. Manipulation and exploration are practically a single activity in the child's play. If any object awakens his curiosity he is not satisfied to look at it but tries to get it into his hands. He makes the object perform and so learns how things behave in the world. This observant manipulatory play is of immense importance in the acquisition of knowledge and skill.

Social motives. Man is so much a social animal that even such an organic need as hunger gives rise to social behavior. Fear and especially anger are oftenest aroused by other people. Sex behavior brings people together in pairs, and maternal behavior gives us homes and families. Thus many motives become socialized. The question remains whether

there is any primary social motive. The herd instinct, or gregarious instinct, is often spoken of as such a motive. Man belongs with the more gregarious animals, the deer and the wolf, rather than with the so-called solitary animals like the lion. But it is very difficult to decide whether man's preference for living, working and playing in groups is learned or unlearned. From his prolonged period of dependence, the human child is bound to be "conditioned" to group life, even if he were naturally indifferent to it. Learned or unlearned, the social motive is strong and dependable. It is a love not simply for company, but for participation in the activity of the group.

Overcoming resistance—the mastery motive. Let the individual be engaged in any activity whatever, and moving toward any goal, and let him encounter an obstacle. What will be his natural reaction? Several reactions are possible. He may stop, give up, yield to the obstacle. This possibility will be considered a little later. He may make a detour, i.e., engage in trial-and-error behavior (p. 294). He may become angry and make a pugnacious attack on the obstacle, as we have already said. Simpler and more common than this emotional reaction is the reaction of effort which we will now consider.

Effort. The most common immediate response to an obstacle consists in pressing toward the goal with increased energy. The drive toward a certain goal persists and an additional drive comes into play directed toward overcoming the obstacle. More muscle is thrown into the activity. The "trend" here is *from* being blocked or impeded in one's activity and *toward* overcoming the external resistance and resuming free movement toward the goal.

This drive toward overcoming resistance is certainly unlearned. Obstruct a movement that the little baby is making and you can feel him putting increased force into the movement. Take his foot in your hand and force it this way and that, and you will find his muscles acting to overcome this external compulsion. These are natural or unconditioned

reflexes and can be experimentally demonstrated in adults as well as babies.

A more complicated reflex of the same sort is the movement of straining: a full breath is taken, the glottis is closed preventing the escape of air from the lungs, and then a strong movement of expiration is made. The most obvious result of this peculiar movement is to produce pressure in the abdomen and so assist in the evacuation of the bladder or rectum; and that is the way the baby first uses it. But it also sets the chest and stiffens the whole trunk for lifting a heavy weight or for any great muscular strain, and it regularly enters into any such muscular effort. It is the typical reflex of effort, a natural reflex that becomes attached to all sorts of effortful reactions, and conditioned to all sorts of difficult situations. Careful observation will show that it occurs dozens of times a day, even where the effort required is more mental than muscular.

There are many other movements of effort: gritting the teeth, clenching the fist, stiffening the neck, frowning in the effort to see better, leaning forward for the same purpose, even when, as at a football game, getting a foot or two nearer the show cannot make any noticeable difference to the eyes. Ask a child just learning to write why he grasps the pencil so tightly, why he bends so closely over the desk, why he purses his lips, knits his brow and twists his foot around the leg of the chair, and he might answer, very truly, that it is because he is *trying hard*. All this muscular effort shows the release of extra energy by the difficulty encountered.

A good example of overcoming resistance at the mental level is afforded by the distraction experiment (p. 49). When a person who is engaged in any activity is suddenly subjected to a distracting stimulus, he may give up and attend to that stimulus, but he is very apt to thrust the distraction aside and throw more energy into the work.

Any experiment on learning a new performance shows effort to overcome the difficulty of the unaccustomed task. When the beginner has passed the first cautious, exploratory stage of learning, he begins to "put on steam." He pounds

the typewriter, if that is what he is learning, spells the words aloud, and in other ways betrays the great effort he is making. Once he has mastered the difficulties of the performance, he reaches a free-running stage in which great effort is no longer required, unless it be for making a record. With reference to effort, then, we may distinguish three stages of practice: the initial, exploratory stage, the awkward and effortful stage, and the skilled and free-running stage.

As a general proposition, and one of the most general propositions under the head of motivation, we can state that obstruction encountered in carrying out any activity stimulates the individual to put more energy into the activity.

The mastery motive. Such satisfaction comes from overcoming an obstacle that the human child *learns to go out and find obstacles* so as to have the pleasure of surmounting them. He likes to master things that offer some difficulty. If the child has a horn, he is not satisfied till he can sound it himself. The man with his automobile is no different. When it balks, he is stimulated to overcome it; but when it runs smoothly for him, he has a sense of mastery and power that is highly gratifying. Chopping down a big tree, or moving a big rock with a crowbar, affords the same kind of gratification; and so does cutting with a sharp knife, or shooting with a good bow or gun, or operating any tool or machine that increases one's power over things. Games and sports are so devised as to present obstacles that can be overcome by strength, skill or good luck. Quite apart from its utility, any achievement is a source of satisfaction. The mastery motive, or zest for achievement, while probably based on the primitive drive to overcome an obstacle, is more outgoing and depends on experience.

Socialized forms of the obstacle-overcoming and mastery motives. A large share of the obstacles encountered by the child originate in other people, who prevent him from doing what he wishes and try to make him do what he does not wish. Practically all the "conditioning" that the child gets should tend to make him meekly submissive and not masterful in the least. A weak, dependent creature, he is sur-

rounded by big creatures who do everything for him and expect him to yield and obey. But the child shows from an early age that he has a "will of his own." He seems to take pleasure in having his own way in opposition to the commands of other people. He *resists domination* and exerts himself to overcome the restrictions imposed on his freedom of action.

The child not only strives to overcome the social obstacles that are placed in his way, but he also shows a masterful spirit of the more positive, outgoing type. He *seeks to dominate.* Even the baby gives orders and demands obedience. He discovers less direct ways of dominating other people as he grows older. Showing off is one way, bragging is one, doing all the talking is one; and, though in growing older and mixing with people the child becomes less naive in his manner of bragging and showing off, he continues even as an adult to seek applause and social recognition. Anything in which one can surpass another becomes a means to this end.

Rivalry and *emulation* belong on the social side of masterful behavior; they aim at dominating others or against being dominated by them.

Though acquired in the process of dealing with other people, these motives have the same general unlearned trend as the primitive behavior of overcoming an obstacle. Competitive behavior is probably present in every culture and social group, but the form it takes depends on circumstances and on the traditions and ideals of the group. In some cultures, and in many informal friendly groups, boasting is strictly taboo and the way to secure social recognition is to be of service. Good teamwork is not inconsistent with friendly rivalry between the members, but the rivalry takes the form, not of playing to the grandstand, but of doing one's bit toward the success of the team.

When the mastery motive is thwarted, a variety of queer emotional states may appear. Shame, sulkiness, sullenness, peevishness, stubbornness, defiance, all spring from "wounded self-assertion." Envy and jealousy belong here, too. Shyness and embarrassment occur when one is eager for recog-

nition but doubtful of winning it. Opposed to all these are self-confidence, the cheerful state of one who fully expects to master the obstacle or the opponent, and elation, the joyful state of one who has achieved mastery.

Submission. Is there an unlearned, primitive drive toward giving up in face of an obstacle, or submitting to the domination of another person? At first thought we say, "No. How can the individual have two contrary drives?" But this is no argument, for the individual may have conflicting motives, responsive to different types of situation. In fact, the outgoing tendency to explore a strange locality is opposed by timidity, as we saw in the case of the rat in the maze (p. 300). So, in face of an insuperable obstacle, the individual does give up, and he yields to external compulsion when the compulsion is forcible enough. At first thought we say the individual is passive in these cases, and simply forced to yield, as a stone is brought to a stop when it strikes a wall. In reality, giving up is not quite so passive as this. There is no external force that can absolutely compel us to yield, unless by clubbing us on the head or somehow putting our brain, nerves and muscles out of commission. If we cease struggling while still able to struggle, our giving up is not passive but our own act. It would seem to be a very primitive kind of response. When struggling against an obstacle, we sometimes feel an *impulse to give up*, and yielding brings relief. The child has plenty of chances to learn submission, but there is some ground for belief in the unlearned drive.

Whether the ability to submit is partially unlearned or wholly the result of training, it is surely an asset in the great task of adapting oneself to the environment. Absolute stubbornness would prevent all learning by trial and error. An absolutely stubborn cat in a puzzle-box would persist in pushing its nose between the bars, if that were its first reaction, and would never find the latch that opens the door. Final mastery often depends on giving up the first line of attack and trying something else. Adaptability, docility, openness to new facts and ideas, impartiality and fairness, all contain an element of submissiveness.

Yielding to the domination of other persons often occurs unwillingly, and then belongs under the head of "thwarted self-assertion," but the question is whether it ever occurs willingly and affords satisfaction to the individual who yields. We certainly yield with good grace to one who so far outclasses us that competition with him is unthinkable. Hero worship is a good example of willing submission. There are individuals who are "lost" without a hero, and all of us are glad to follow the leader at certain times. These socialized forms of submissive behavior depend on learning, but may involve a primitive tendency to yield to superior force.

Likes and dislikes. Besides the motives which are "trends of activity," there are learned and unlearned tastes, or likes and dislikes, that seem rather passive and independent of any activity in which the individual may be engaged. Sweet is liked and bitter disliked, just for themselves. Certain odors are liked and others disliked. Bright colors are liked; smooth tones are liked; simple rhythms are liked. These likes and dislikes do not have to be learned, whereas the liking for lemonade, coffee, olives or cheese has to be acquired by learning, as is true also of the liking for subdued colors or for close musical harmonies.

Such likes and dislikes are motivating factors in the development of the arts. The culinary art could not have developed in the absence of pleasant tastes, nor the perfumer's art in the absence of pleasant odors. The color art is certainly dependent on human love of color, and music on love for tones and rhythm. Once these arts are in existence, the artists find opportunity in them for the mastering of technique, and for self-display and social prestige, but the basic motivation still lies in the unlearned likes and dislikes.

Classification of unlearned motives. Though a bitter taste is not the same as a burn on the hand, and though the motor response is different in the two cases, in both the act consists in getting rid of the stimulus. Other avoiding reactions can be classed with these two as having very similar trends. In exploring the environment the individual finds a variety of things having objectionable characteristics, things that he

learns to avoid. For want of a better name, we may speak of a class of "bad objects." The individual's trend with respect to this class of objects is toward avoidance and *security*.

There are also good objects, "goal objects." The trend is to approach and appropriate them. Some of them, like food or drink, satisfy an organic need; others, like a sweet odor, appeal to a natural liking. If we disregard the animals and rely upon our human experience, we can class all these objects as pleasurable, and the trends toward appropriating them we can regard as trends toward *pleasure*.

Besides definitely good and bad objects, there are strange objects and obstacles. With respect to strange objects, the trend is toward exploration and manipulation, or, we might say, toward *acquaintance* with the environment. With respect to obstacles, the trend is toward *mastery*. By lumping things together rather freely we might combine acquaintance and mastery under some such name as *achievement*.

Evidently the unlearned motives could be classified in various ways. No classification is perfectly valid except as a matter of convenience. Thinking of human life we may find it convenient to speak of a few major demands which the individual makes on the physical and social environment. He demands security, pleasure and opportunity for achievement. Individuals differ in the insistence of these demands, some being anxious above all for security, others being willing to take risks in the pursuit of pleasure, and still others having a keen zest for achievement of one kind or another. The kind of security or pleasure desired also differs with the individual. These individual differences are probably due partly to heredity and partly to environment.

LEARNED MOTIVES: ATTITUDES, INTERESTS, PURPOSES

Equipped with a list of primary needs and natural demands of the individual, a student of motivation may think himself fully prepared to interpret the behavior of adults and to make practical use of his knowledge. To secure action from him-

self or other people he would simply have to provide incentives appealing to the hunger drive, the sex drive and the rest. But how would a teacher, for example, or an athletic coach, motivate his class or team to high endeavor? He could appeal to the exploring and mastery motives, but he might find his group little interested in the activities he wished them to undertake. Some individuals would be more interested than others in any particular activity. He would be forced to the conclusion that motives become complex and specialized as the individual grows older, and he would insist that psychology should advance from the study of primitive drives to an investigation of adult interests, attitudes and purposes.

Modification of the primitive drives. We need not assume, and had better not assume, that all adult motives stem from a few primary drives, modified and combined in various ways. Radically new motives may emerge from the environment, or better from the individual's dealings with the environment. However this may be, the primary drives do persist throughout life and are modified in various ways as the result of the individual's experience. The unlearned trend remains the same while the behavior is much changed through learning. It is changed in several ways.

1. New motor responses. Examples of this kind of modification have already been given. The adult's eating behavior differs from that of the hungry child. In part the change is due to social influences, and in part it is because the adult is responding to different foods, *different incentives.* His motor behavior is adapted to the incentive, the object dealt with. So it is with other drives. Where the little child fights with his teeth, nails and feet, the adult is more apt to use his tongue. Both are angry, both show the same trend toward damaging the adversary, but they use different weapons. The adult does not care especially to bruise his opponent's skin but he would like to damage his reputation or lower his social prestige.

In the same way, exploring behavior takes various forms, such as asking questions, reading a story to see how it comes out, or reading the news to see how things are going in the

world. The range of curiosity becomes widely extended.

2. *New stimuli.* Examples have already been seen in conditioned fears and acquired tastes. Some interesting experiments have been concerned with the possibility of eliminating unnecessary fears or of developing new tastes and preferences.

Peter was a child nearly three years old who for some unknown reason was extremely afraid of a rabbit. The experimenter undertook to remove this fear by a process of "conditioning." The plan was to have the rabbit present while the child was enjoying his lunch. At first, when the rabbit was placed close to the child, fear predominated and might easily have spoiled the lunch. Without the exercise of tact, the conditioning would have been in the wrong direction (as the combination of orange juice and cod liver oil may make some children hate orange juice rather than like cod liver oil). So the experimenter placed the rabbit in his cage quite far away from the child who was then able to tolerate the rabbit's presence without loss of pleasure in his lunch. Day by day the rabbit was brought nearer, Peter continuing to tolerate the situation. Finally the rabbit could be placed right on the lunch table and taken from his cage. Peter began playing with him, even without the aid of any lunch (*6*, 7).

What happened here was that the child saw the rabbit in a favorable light because of the agreeable nature of the whole situation and because of the unobtrusiveness, at first, of the fear-provoking rabbit. A somewhat similar experiment was carried out by a group of educated adults. The experimenter handed a (harmless) garter snake to one of the group who was required to hold the snake for 10 seconds and then to rate the experience on a scale of pleasantness and unpleasantness. Each member of the group did the same, and the experiment was continued for 15 sessions, two a day. On the first trial the experience was rated quite unpleasant by most of the subjects, but by the tenth trial some were finding it pleasant and the average was just at the point of indifference. Many of the subjects helped the situation by giving the snake a pet name. Doubtless all of them discovered that the snake

did not bite and was not slimy to the touch. Oftentimes acquaintance with an object shows it to be better or worse than had been assumed beforehand, and so the emotional reaction is changed (*12*).

In still another experiment, pictures shown or musical selections played to a group of students during an agreeable lunch period rose in the scale of preference. Being in an agreeable state of mind, the subjects were disposed to make favorable responses, and this favorable attitude to these particular objects was retained even after the lunch period was over (*9*).

What we shall see in an object and how well we shall like it are determined in the first instance by the total situation, including our own state and the setting of the object. When we have once been led to take a certain attitude toward an object in a certain total situation, there is a good chance that we shall revive the same attitude even when the object is seen in more neutral conditions (cf. some remarks on recognition, p. 357).

Often a shift from an unfavorable to a favorable attitude is rewarded in one way or another, and so reinforced. One who finds himself overcoming a fear has a gratifying sense of new freedom, and his newly found courage is probably applauded by his friends. Social approval is given to likes and dislikes that conform to the custom of the group and so the attitudes of members of a group are standardized to a considerable extent.

In getting acquainted with the world, then, the individual discovers new stimuli capable of arousing his primitive drives. He finds new dangers to avoid, new enemies to fight, new obstacles to overcome, new objects to like and dislike. And he unlearns many old fears, likes and dislikes.

3. Combination of motives. The same object may be an incentive for more than a single drive. To take a very simple instance, an orange attracts a person who is hungry, or one who is thirsty, or one who relishes an agreeable flavor, or one who admires its gorgeous color and symmetrical shape. Experience with oranges builds up in the individual a compound

attitude toward that fruit. A host of similar examples could be given. One of some importance is the growing boy's attitude toward his father. Big and strong and exciting in his play with the boy, the father becomes an object of admiration and hero worship. He seems to the boy to possess unlimited power and knowledge. As a kind father, he is the object of affection. But he will not always play with the boy or do his bidding; he issues commands, imposes restrictions on the boy's freedom of action, reprimands or punishes at times and is the source of authority which the boy resents. The little child tends to be all-or-none in his reactions. At one time he is all for his father, at another time, all against him. As he grows up the boy develops a more balanced, understanding attitude. The father, we may say, is a problem to the child, a problem in motivation; and the solution lies not in following any one primitive drive but in developing a new, compound drive, adjusted to the father's complex role and personality.

Attitudes. Continuing the previous topic, we can define an attitude as a set or disposition (readiness, inclination, tendency) to act toward an object according to its characteristics so far as we are acquainted with them. Several points in this definition will bear a little further consideration.

1. Set or disposition. An attitude is built up in the process of getting acquainted with the object. It is a learned motive and like other learned responses is not in action all the time. It is retained in an inactive state and is aroused to activity by suitable stimuli. When it is active it conforms to our general definition of *set* (p. 32). When it is inactive it may be called a *disposition*. So we may say that a person has a critical attitude or disposition toward politics. He is disposed to take an active critical attitude or set whenever the subject of politics is mentioned.

2. Acting toward an object. The action may be confined to talking or even to silent thought. As Mark Twain remarked, everybody is disposed to find fault with the weather, but nobody seems to do anything about it. From the individual's own point of view, an attitude is a *feeling* rather than

an overt action. Your attitude toward a certain person is expressed by saying that you feel sympathetic or antagonistic toward him. You feel amused at a certain person, you feel dubious about a certain proposal, you feel inclined to sit in the comfortable chair. Very many attitudes are known to the subject as feelings. When the feeling is at all strong the attitude is called a *sentiment.* Such sentiments as love, hate, ambition and patriotism are powerful motives in adult life. They are not primitive drives but are learned and built up in the course of experience (*8*).

3. Characteristics of the object. If all we knew or cared about objects was the answer to the question how good or bad they are for us, we could arrange all our attitudes on a scale extending from most favorable to most unfavorable. If we try to do so with a miscellaneous list of objects, such as

> classical music, aviation, hammer and nails, detective stories, snow, slippers, the ocean,

the objects make such a variety of appeals that our attitudes are not comparable. What we discover in an object is much more specific than its degree of goodness or badness, and our attitude is adjusted to the nature of the object.

4. Acquaintance with the object. We have been speaking as if the individual got to know the object by his own observation, but often his acquaintance is secondhand. He accepts what others tell him and forms an attitude accordingly. He takes over the attitudes that are current or traditional in his social group. Many prejudices, some of them quite irrational, are founded on "They say."

An attitude may persist after the "acquaintance" has lapsed. We dislike a person though we have forgotten why. We may have been conditioned for or against a person or thing in childhood, and our retained childish attitude may be quite different from what we should derive from a fresh investigation. So we carry around with us a lot of superfluous prejudices and probably some foolish enthusiasms.

Unconscious motives. This word, "unconscious," is responsible for a good deal of mystification in psychology.

There used to be much talk of "The Unconscious," regarded as a separate part of the personality, but this way of talking has largely gone out of fashion. Your attitude toward a person, or your motive for an action, may be complex and difficult to analyze. If you do succeed in analyzing your motive for an act and formulating it in definite language, then you have to admit that this motive was unconscious before, or only dimly conscious, since it was not formulated, it was not isolated, it was not present in the precise form you have now given it. Yet it was there, bound up in the total activity. It was not unconscious in the sense of being active in a different, unconscious realm. The realm in which it was active was that of conscious activity, and it formed an unanalyzed part of that activity.

In the same way, we do not realize in helping a friend that we are at the same time dominating over him, but think, so far as we stop to think, that our motive is pure helpfulness. Later, analyzing our motives, we may separate out a masterful tendency, which was present all the time and consciously present, but so bound up with the other motive of helpfulness that it did not attract our attention. Now if our psychology makes us cynics, and leads us to ascribe the whole motivation of the helpful act to the mastery impulse, we are fully as far from the truth as when we uncritically assumed that helpfulness was the only motive operating.

The origin of an attitude may be lost in the dim past, but that loss of memory does not make the present attitude unconscious in any true sense. When an individual has an unfortunate "style of life" or an unrealistic code of personal ethics (pp. 180, 185) he does not remember the childhood experiences in which these complex attitudes originated, nor does he see clearly how his present life is being hampered and distorted by these attitudes. He may suffer from an exaggerated feeling of inferiority and be disposed to give up in face of any obstacle; but he tells himself and others that the obstacles are unsurmountable or that he is incapacitated by some strange illness for which he cannot be blamed. As a much simpler, less neurotic illustration of this sort of camou-

flage, take the person who will not yield ground in the least in a debate with his friend. He will say, "Of course not, for my side of the question is right"; but next day in a calmer mood he may see that his real motive was the desire to keep the upper hand or the fear of being worsted. Some people cannot stand the least bit of criticism because they feel that the core of their being is attacked. Some cannot bear to have another person praised, even a famous historical character. They seem to feel the praise of another to be a challenge to themselves. This attitude may go back to childhood when the parents praised one brother or sister as a means of "setting down" the other. The not-praised child was left out in the cold, and the old feeling of insecurity is revived in the adult on hearing anyone praised. In all these cases we have motives that are not understood or analyzed, but they are not really unconscious. Sometimes it is worth while to analyze our own motives, but some individuals do too much of this and would be better advised to leave the past behind and press forward to the most desirable goal that seems at all within their reach (*4*).

Interests. An interest is a kind of attitude. It is obviously not an attitude of indifference or avoidance; it is a positive, approaching attitude. It is the attitude that makes attention to a thing easy (p. 46). How does an interest develop? Many objects—for example, a person, a book, a topic for study, a line of work—which at first sight seem to have no interest become interesting after a little exploration. Some authorities will tell you that all interests are derived from the primitive drives by conditioning and the other processes already described. The present author's view is quite different. He believes that an interest springs from the individual's ability to deal effectively with some phase of the environment. An interest in tools springs from the ability to manipulate them and accomplish results by their use. An interest in music springs from a liking for tones and harmonies, from an ability to follow and appreciate music and perhaps to sing or somehow make music. When a pianist says, "I don't care at all for that particular piece, but I play it sometimes because

it makes a hit with my audience," the pianist's interest in that piece is derived from the drive for social mastery. But when he says of another piece that he likes it because it is such interesting music, and plays it for his own enjoyment, the interest in that piece springs from the music itself and from his ability to appreciate it. When a person says of his job that it is deathly uninteresting and good for nothing except to keep him alive and perhaps enable him to marry, you can trace his motivation for this job back to the primitive drives. But if his job suits him, he forgets the economic motive while actively engaged in the work, for he finds the materials dealt with, and the operations involved in dealing with them, interesting in themselves. At any one time he has a definite goal to reach and becomes absorbed in the activity leading toward that goal. According to this view interests, which are certainly very important motives, spring from the individual's active give-and-take relations with the environment.

Purposes. Though the word "purpose" is sometimes used so broadly as to cover any activity directed to a definite end—any form of goal-seeking—it is better reserved for cases where the individual has some *foresight* of the end. Foresight depends on memory, for the outcome of an act cannot be foreseen except by one who has had experience in performing similar acts and noting their results (pp. 299, 318).

A purpose can be defined as a goal-set with foresight of the results to be obtained. It is an idea of certain desirable or undesirable results motivating activity directed toward obtaining or avoiding those results. You can have an idea of a desirable state of affairs without acting on this idea. When you say, "I'd like to do this, or to have that," your wish is not yet a purpose, but if you go on to say, "I'll do it, I'll get it," you have adopted the wish as a purpose.

Throwing or shooting at a mark affords a simple example of a purposive act. You take aim, you shoot, you watch the effect. The final stage consists in observing the results. You go through one or more preparatory stages in reaching the results. You follow a path to the goal, you take *means* to reach the desired *end*. The time-span of a purposive act, the

time from start to finish, may be only a couple of seconds or may extend to years. The little child's purposive acts have only a short time-span which enlarges as he grows older. His time perspective, both forward and backward, becomes wider and more exact. In the midst of an elaborate planned activity, like cooking a dinner or assembling a machine, the adult has a sense of where he is in the total scheme of the operation. Evidently the planning and execution of a complicated purposive act demands good intellectual grasp as well as energy and persistence.

The purpose behind a particular act is often highly specialized. Just as a learned attitude is more specific than an unlearned drive, so a purpose is more specific than the general attitude toward a person or thing. Your friend starts up and says, "I'm going over to the book store to get a little pocket memorandum book," and you know that he is set to do just that thing. A large share of human behavior is directed to precise ends, often formulated beforehand in words, sometimes in mental images, sometimes in blueprints and models of various kinds.

In several respects, then, a purpose is a motive at the highest degree of development. It can be more elaborate than any other motive, it is often adjusted to the exact character of a certain environment, it may compass a long series of varied acts leading up to the goal, and it is apt to have very great motivating power.

CONFLICT OF MOTIVES

The individual is complex, with many different activities that can be aroused. The environment is complex, affording stimuli for various activities. Conflict, then, is sure to arise, and a choice must be made (*15*, esp. pp. 483-538).

The state of indecision. When a conflict arises, the first result is a state of indecision, this "state" being really a complex activity, often very intense and often very confused. It works itself out, somehow, into the state of being committed to one of the alternative lines of action.

The state of indecision may amount simply to *hesitancy*, when the conflict is between doing something, on the positive side, and fear, shyness or inertia on the negative side. Hesitancy is apt to occur before getting out of bed in the morning, before taking a plunge into cold water, or before speaking out in meeting or in a general conversation. To get action, the positive motive must be stronger than the negative, at least for an instant.

Vacillation is a more complex state of indecision, when the choice lies between two desirable goals, or between two evils. Vacillation is certainly unpleasant. We want action, or else we want peace, but vacillation gives us neither. In spite of its irksomeness, we seem almost powerless to end it, because as soon as we have about decided on the one alternative, what we shall miss by not choosing the other comes vividly to mind, and swings the pendulum its way.

However, a decision is usually reached, and then it usually sticks. A student may vacillate long between the apparently equal attractions of two colleges, but when he finally decides on one, the advantages of the other lose their hold on him. Now he is all for one and not at all for the other. Some people, indeed, are abnormally subject to vacillation and never accept their own decisions as final, but normally a decision, once reached, is fortified by the satisfaction of having a definite course of action and by self-assertion, because *we* have decided, and now this course of action is *ours*.

The process of decision. While the state of indecision and the final state of decision are very different, the process of passing from one to the other is often difficult to trace. It differs from one case to another.

Deliberation. Sometimes each alternative is pictured as well as possible, and weighed against the other. This is ideally rational, but often impracticable, for lack of knowledge of how each line of action would turn out. Even if practicable, deliberation may be too irksome to pursue to the bitter end. Perhaps the most common process is a sort of partial deliberation, the two alternatives appealing to us by

turns till at some moment one of them makes so strong an appeal as to secure the decision.

Incubation of a decision. When a deadlock arises between alternative courses of action, the most rational procedure is usually the same as is found useful in recalling a forgotten name or solving a difficult problem (pp. 350, 588). Let the matter rest for a time, and perhaps sleep over it. On taking the matter up afresh you often find that one alternative has lost its momentary appeal and that the other is clearly superior.

Arbitrary decision. Sometimes a deadlock is so irritating, almost humiliating, that we say, "Any decision is better than none; here goes, then; *this* is what I will do," so breaking the deadlock by what seems to be a mere toss-up.

Does the decision always follow the stronger motive? Logically it would seem that the stronger motive must prevail. But motives have a way of bringing in allies, and then the question becomes, which *team* of motives is the stronger. A primitive craving, pitted against mere self-denial, would have the advantage, but self-respect and loyalty to another individual or to one's social group may line up on the side of the weaker motive and give it the decision.

What becomes of the rejected motives? If you ask a person who has just fought his way through from a state of indecision to a state of decision to reopen the question and consider whether the rejected alternative might not be better, he is very unwilling to go back into the turmoil of indecision; and if he does reopen the question, he usually finds the rejected alternative wholly lacking in pulling power. The process of decision has deadened the rejected motive. Thus the rejected motives may simply *lapse* into an inactive state and be gradually forgotten.

A deeply rooted motive, which cannot be so easily eliminated, may often be quieted by *deferring* it, by assuring it that its turn will come later on. Sometimes it is *disguised* and then gratified, as when an outwardly courteous action contains an element of spite. Sometimes it is allowed a *modified gratification*, as when the boastful boy, after having the con-

ceit taken out of him by his fellows, boasts no longer of himself but of his school, town or country. Sometimes it is tricked by *defense mechanisms*, such as the "sour grapes" mechanism, a pretending that we don't want what we can't reach or what we have decided not to touch.

Some motives are *repressed* in the sense emphasized by the psychoanalysts. A strong but unacceptable desire is forbidden, thrown out of gear, banished and forgotten as far as possible, while still retaining its force and finding gratification in dreams and in major or minor disturbances of waking life. Sometimes the desire for a particular thing is replaced by a senseless fear of that same thing. Repression grows out of an unresolved conflict (p. 349).

The most adequate way of handling rejected motives is to *co-ordinate* them with accepted motives—to harness them into teams and set them to work. This cannot always be done; for example, if a young woman has two attractive suitors, she may find difficulty in harnessing them together. But when the boastful boy becomes a loyal and enthusiastic member of a school, his self-assertive motive is combined with social motives into an effective team.

These various ways of handling a rejected motive can be illustrated in the case of the sex motive. It so happens, in part because modern economic and educational conditions enforce a delay in marriage, and in part simply because there are so many attractive people in the world, that the cravings of sex must often be denied. What becomes of them? Of course the sex motive is too deep-seated to be eradicated. But the fascination for particular individuals may lapse and be forgotten. Certain people we remember, once in a while, with half-humorous and certainly not very poignant regret. Deferring the whole matter till the time is ripe works well with many a youth or maiden. Combined with social interests, the sex motive finds modified satisfaction in a great variety of amusements, as well as in business associations between the sexes. Introduce an attractive girl into an officeful of men, and the atmosphere changes—which means, certainly, that the sex motive of these men, combined with ordinary business

motives, is finding a modified satisfaction. The sex motive thus enters into a great variety of human affairs. Defense mechanisms are common in combating erotic impulses; the "sour grapes" mechanism sometimes takes the extreme form of a hatred of the other sex; but a very good and useful device of this general sort is to throw oneself into some quite different type of activity, as the young man may successfully work off his steam in athletics. Athletic sport does not gratify the sex tendency in the least, but it gratifies other tendencies and so gratifies the individual. It is the individual that must be satisfied, rather than any specified one of his tendencies. As regards co-ordination, the fact was illustrated just above that this method would not always work; but sometimes it works immensely well. Here is a young person (either sex), in the twenties, with insistent sex impulses, tempted to yield to the fascination of some mediocre representative of the other sex. Such a low-level attachment, however, militates against self-respect, work, ambition, social sense. Where is the co-ordination? It has to be found; some worthy mate will harness all these tendencies, stimulating and gratifying sex attraction, self-respect, ambition and others besides, and co-ordinating them all into the high-grade sentiment of love.

MOTIVATION OF WORK

It would be more satisfactory, in approaching the practical side of the subject, to entitle this section, "Motivation of work and play" or in some such way to promise information on the important problem of securing and retaining affection, fostering friendly relations and increasing the enjoyment of social life, by use of suitable incentives. A young wife wishes to keep her husband as much in love with her as he is during the honeymoon. She has a problem of motivation on her hands, and there are many such problems on which commonsense advice, "words of wisdom," could be offered but not much that is sure or scientific. We can safely recommend an outgoing, optimistic attitude rather than recourse to such

negative suggestions as, "You don't love me any more" or, to a child, "You are a bad boy and will be a disgrace to the family." The suggestions might be taken to heart, and at any rate they create a barrier which interferes with confidential, friendly relations. Somewhat similar is the bad effect of obvious effort or artfulness on the part of one who is anxious to make a good impression.

A genuine play situation fosters spontaneity and usually secures excellent motivation. Children who hang back from a certain piece of work will do the same thing eagerly if it is somehow made into a game. Not being commanded, they are not stimulated to resist and are left free to immerse themselves in the activity and find something interesting in the materials, operation and social give-and-take involved in the game. There is a suggestion here for anyone concerned with the motivation of serious work.

Suggestions from the laboratory. From numerous experiments on motivation a few are selected which demonstrate the effectiveness of certain incentives.

Competition. Pass a dynamometer around a group of men asking each to try squeezing it as hard as he can. You tell the first man his squeeze in pounds and hand it to the second man who perhaps does better than the first. At once the first man wants to try again and visibly exerts himself more than before.

Pacemaking. This is an outdoor rather than a laboratory experiment. A runner can make better time against a competitor than when running "against time." He does better when paced by a bicycle rider who keeps just a little ahead of him than when running alone. The pacemaker is not a genuine competitor, and the runner does not really desire to overtake him. What, then, is the use of the pacemaker? The best answer is probably that the pacemaker provides an immediate goal, always close ahead of the runner, calling for the runner's best effort moment by moment. A distant goal is less stimulating.

Self-competition. A similar result can be obtained without a trace of competition between individuals. You give the

subject a series of trials at the same performance and before each trial you tell him his record on the preceding trial. He will usually try to beat his previous record. The practice curve (p. 321) can be used as an effective incentive. You plot the curve as the experiment progresses so that on each trial the subject knows what he has done from the beginning. This practice with "knowledge of results" gives the subject at every stage something very definite as an immediate goal.

The output of muscular work can be considerably increased by these incentives. In one experiment the subject lifted a weight time after time with one hand (by pulling on a cord which passed up over a pulley and was attached to the weight at the other end). The apparatus made a visible record of each pull, and the question was how many times the subject could and would lift the heavy weight, one lift every two seconds, before giving up. In one condition the subject did not see the record being made but simply did "as much as he could." In another condition he saw the record as he made it and also saw ahead of him on the record a mark placed there by the experimenter as a goal. If he could reach this goal he would surpass his previous achievement. Under this latter condition he got 20-40 percent more work out of his muscles, at the cost of some extra fatigue. In this experiment motivation came from the visible goal and the immediate knowledge of results (*1*).

Very different from muscular effort is accuracy of observation, but this too is improved by prompt reward for an accurate job or punishment for inaccuracy. In one experiment the "reward" was simply a bell ringing whenever the subject had done a very accurate job in his effort to divide a line into halves by the unaided eye. Under this stimulation his accuracy improved far beyond the point reached by simply trying to do his best, time after time, with no knowledge of results (*3*).

The pacemaker and similar experiments show the great value of visible, immediately attainable goals and the value of prompt check-up on results accomplished. These incentives can be used in many practical situations.

Will and will power. We are not to think of the will as a special faculty or source of energy. Willing is a way of acting. To will is to decide between conflicting motives, or to exert effort in overcoming an obstruction, or to undertake a purposive course of action. A typical instance of willing occurs when a person has failed in some attempt but now has another chance. He says, in effect, "That was stupid of me. I can and will do this thing." His self-feeling is aroused and leads him to mobilize his resources and concentrate them on a particular task. Willing consists in concentrating one's powers into a specific act.

The "powers" that are mobilized include motives and abilities. Such instances as the following are typical.

(a) "My friends ask me to join their party, but I must not do it and will not do it, because . . ." Here the subject marshals the reasons and builds up motivation against the act.

(b) "I don't seem to manage this thing right but I'm determined to get it right. Let me observe carefully and see where the difficulty lies. . . . I see now. I must remember next time." Here the subject is marshaling his powers of observing and remembering.

"Will power" is not a mysterious, almost supernatural power possessed by some individuals and enabling them to control other people as well as themselves. As far as we know, other people are controlled only by motivating them, only by providing incentives or conditions that awaken their own desires, interests and drives.

Abulia—"no will"—is an abnormal lack of zest for action. Along with it go timidity, proneness to daydreaming, and often a feeling of being compelled to perform useless acts, such as doing everything three times or continually washing the hands. Abulia is not comfortable laziness, but is attended by a sense of humiliation and inferiority. It shows itself in excessive hesitation and vacillation and in failure to accomplish anything of consequence. Sometimes the subject expends much effort, but fails to direct the effort towards the execution of his purposes. Some authorities have ascribed abulia to inertia or "low mental tension," some to an overdose

of fear and caution, some to the paralyzing effect of repressed desires still living in the "unconscious." Mild degrees of it, such as are not uncommon, seem sometimes to be due to the distance of the goal. One has zest for reaching the goal, but not for the preliminaries.

An author, whose case was studied because he was accomplishing so little, was found to follow a daily program about as follows. He would get up in the morning full of confidence that this was going to be a good day. Before starting to write, however, he must first have his breakfast, and then a little fresh air, just to prepare himself for energetic work. On returning from his walk, he thought it best to rest for a few moments, and then one or two little matters seemed to demand attention; by the time these were done, the morning was too far gone, and he postponed writing till the afternoon, when the same sort of thing happened, and the great performance had to be put over till the next day. This man did better under a regime prescribed by his medical adviser, who commanded him to write for two hours immediately after rising, and make this his day's work—no more and no less than two hours. The definiteness of this task prevented dawdling.

How to secure action from yourself, or from others if you are responsible for their action, is a big practical problem. A few hints on the matter are suggested by what precedes.

How to get action from yourself—how to liberate your latent energies and accomplish what you are capable of accomplishing. A definite purpose is the first requirement; without that one merely drifts. The goal should be something that appeals vitally to you, and something which you can attain; not too distant a goal; or, if the ultimate goal is distant, there must be landmarks along the way to strive for as immediate goals; for a goal that can be reached by immediate action enlists more present effort. The student puts more energy into his study when the examination is close at hand; and, although this fact is regrettable, it reveals a side of human nature that can be utilized in the management of yourself or others.

The more clearly you can see your approach towards the goal, the more action. You cannot do so well when you simply "do your best" as when you set out to reach a certain level, high enough to tax your powers without being quite out of reach. You cannot jump so high in the empty air as you can to clear a bar; and, to secure your very best endeavor, the bar must not be so low that you can clear it easily, nor so high that you cannot clear it at all.

Getting action from other people is the business of parents, teachers, bosses, officers, and of everyone who wishes to influence another. In war, the problem of *morale* is as important as the problem of equipment, and was so recognized by all the armies engaged in the World War. Each side sought to keep the morale of its own soldiers at a high pitch, and to depress the morale of the enemy. Good morale means more than mere willingness for duty; it means a positive zest for action. Some of the means used to promote morale were the following. The soldier must believe that his side has the right and will eventually win. He must be so absorbed in group activities as to forget, in large measure, his own private concerns. Not only must he be enthusiastic for cause and country, but he must be strong for his division, regiment and company. Much depends on the officers who directly command him. He must have confidence in them, see that they know their business, and that they are looking out for the welfare of their men as well as expecting much from them (*15*, esp. pp. 190-265, 388-432).

The manager of an industrial enterprise has the same problem of morale to meet. It is his business to get action from people who come into the enterprise as servants. The main difficulty with the master-servant relation is that the servant has so little play for his own mastery motive. The master sets the goal, and the servant has submissively to accept it. This is not his enterprise, and therefore he is likely to show little zest for the work. He can be driven to a certain extent by fear and economic want; but better results, and the best social condition generally, can be expected from such management as enlists the individual's own will. He must be

made to feel that the enterprise is his. He must feel that he is fairly treated, and that he receives a just share of the proceeds. He must be interested in the purposes of the concern and in the operations on which he is engaged. Best of all, some responsibility must be delegated to him, some room left for the exercise of his own initiative.

"Initiative"—that high-grade trait that is so much in demand—seems to be partly a matter of imagination and partly of motivation. It demands inventiveness in seeing what can be done, zest for action, and an independent and masterful spirit.

Summary of the chapter. The problem of motivation is brought home by the fact that an individual often fails to measure up to his abilities. He needs incentives that make an effective appeal to his natural and acquired motives. Unlearned motives consist largely of the organic needs, but not entirely since the individual has a fundamental orientation toward the environment with a tendency to explore and manipulate objects and overcome obstacles by putting in greater effort. He thus becomes acquainted with the environment, adjusts himself to it and masters it to some extent. In the course of this experience with the environment he builds up new interests and attitudes which are the motives most effective in adult behavior. Motives often become unconscious in the limited sense that they are merged with other motives and difficult to analyze and identify. Conflict of motives often arises and is resolved in various ways that are advantageous or disadvantageous to the individual's happiness. Laboratory experiments yield some useful suggestions toward managing a situation so as to provide good motivation for work. Prompt knowledge of results is one suggestion. War experience also offers suggestions on how to promote morale in a working group. A few suggestions are offered on the motivation of play, friendship and social enjoyment.

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Chapter XII

Feeling and Emotion

FROM a purely objective and social point of view, it may make no difference how the individual feels, if only he goes through the right motions, but that is not the individual's way of looking at the matter. From his personal point of view feeling and emotion could not be omitted without missing the point of the whole story. A psychology without them would be on a par with a motion picture of an orchestra in action, without the sound.

As popularly understood, the emotions are the desires or at least include the desires, aversions, impulses and interests, already considered in our chapter on Motivation. On analysis a desire proves to be a tendency to action and at the same time an emotional state of the individual. When you desire something you have a definite set or attitude directed toward getting that thing, and at the same time you feel strongly about it and as an organism you are not in your usual placid state. When you are angry at a person you not only seek to do him some damage but you are in an excited state. When you are afraid of an animal you not only have the attitude of escape but you are in a state of fear. In any desire we can distinguish, for purposes of scientific study, two main problems: (1) the problem of attitude or motive—"What is the individual trying to do?" and (2) the problem of feeling and emotion—"What is his internal state?" His state can be discovered partly from his own introspective testimony as to how he feels, and partly by objective study of his bodily condition. The state and the attitude are obviously not sep-

arate in reality, both being parts of an integrated activity of the organism as a whole.

FEELING

We have already had occasion to employ the word "feeling" in two connections. We spoke of the feeling of familiarity as having various nuances according to our past experience of the person or thing now recognized (p. 357). And we noticed that many attitudes were also known as feelings (p. 393). In conversation it means the same whether you speak of your attitude toward a person or of your feeling toward him. It is remarkable how many words there are in common use for different feelings. It would be no great task to find a hundred words, some of them no doubt synonymous, to complete the sentence, "I feel . . ." Here are a few names of feelings and emotions, roughly grouped into classes.

Pleasure, happiness, joy, delight, elation, rapture
Displeasure, discontent, grief, sadness, sorrow, dejection
Mirth, amusement, hilarity
Excitement, agitation
Calm, contentment, numbness, apathy, weariness, ennui
Expectancy, eagerness, hope, assurance, courage
Doubt, shyness, embarrassment, anxiety, worry, dread, fear, fright, terror, horror
Surprise, amazement, wonder, relief, disappointment
Desire, appetite, longing, yearning, love
Aversion, disgust, loathing, hate
Anger, resentment, indignation, sullenness, rage, fury

The first word in each class is intended to give the keynote of the class. Other classifications could be made, and the classes could be made broader or narrower. Two broad classes, pleasant and unpleasant, would include most of the feelings. Still, you cannot say that the names simply designate different degrees of pleasantness or unpleasantness. Rapture and hilarity are both intensely pleasant, but scarcely the same; nor are fear and disgust the same, though both un-

pleasant. The fact is that there are many kinds of pleasant feeling, and of unpleasant. Some of the words do not indicate whether the feeling is pleasant or unpleasant; excitement may be happy excitement or unhappy excitement, and the same is true of expectancy and of surprise.

Wundt's three dimensions of feeling. This great leader in experimental psychology (who established the first active psychological laboratory in 1879) hoped to introduce some order into the motley variety of feelings by a system of three dimensions, analogous to latitude, longitude and altitude, by reference to which any actual feeling could be completely located. States of feeling can be arranged in a series from the most pleasant down through lower degrees of pleasantness and through a neutral zone over into the minor and then the major degrees of unpleasantness. This pleasantness-unpleasantness dimension was universally recognized and commonly assumed to be the only scale of feelings. But states of feeling can be arranged in another series, from the most excited to the most calm, quiet, subdued or numb. Wundt proposed, then, to take numb feeling as the reverse of excited feeling, and thus he had his second dimension, excitement-numbness. For his third dimension, he selected tenseness-release, which might also be called expectancy-release. In expectancy you are waiting for something to happen, in relief or release something has happened and abolished the expectancy (*20*).

Wundt's scheme has some value, even though it is almost too neat to fit all the facts of feeling. There may be other dimensions worthy to be placed alongside of these three, such as familiarity-strangeness.

Feeling distinguished from overt action. Feeling is internal rather than overt activity. Whereas overt activity deals with external objects, feeling by itself produces no external results. Yet feeling is not out of touch with the external situation. Unpleasant feeling favors getting rid of something and changing the situation; pleasant feeling favors keeping things as they are. But the feeling can be there without any definite overt action to maintain or change the situation; and on

the other hand, overt action can occur with a minimum of feeling.

Feeling distinguished from observation of facts. Feeling is different from knowing. It does not consist in knowing facts of the world outside us, nor even in knowing facts regarding ourselves. A pain may be simply felt, or it may be observed as the indicator of some fact. A pain from the region of the stomach may be noticed carefully with the object of deciding whether it is the pain of indigestion or a hunger pang; or it may remain simply a painful feeling. Sensations, then, can be taken in two ways. In observation, we take them as indicators of facts, while in feeling we take them as a mass.

Feeling at one time is strong, even overwhelming, while at another time it exists only as an undercurrent. Or we may call it a background, the foreground consisting of the facts observed and the acts intended at the moment. Only a few among the sensations present at any moment are actually used as indicators of facts; the rest of the mass remains unanalyzed and indefinite. When you feel dull and heavy, if you notice the details you become aware of dull pain in the eyes, neck, elbows or knees and of pressure in the chest and abdomen; these sensations, when taken as an unanalyzed mass, constitute the general dull feeling.

The dull, uncomfortable feeling that is apt to occur during protracted sedentary work can be relieved by limbering up the joints with a little exercise, or by lying down for a few minutes. The various dull pains from the joints and from the interior of the trunk are removed by these means.

The background of bodily feeling may be almost lost when one is absorbed in watching something, doing something or thinking of something. Bruises received during an active game may remain unnoticed till the game is over. Eye ache remains unnoticed while the story lasts. The audience sit motionless while the speaker is at his best, and start easing their several discomforts as soon as he becomes tiresome. Thus feeling is dominated and kept down by absorption in activity.

Observation of facts and dealing with them belong together in what is sometimes called the life of relation with the environment, while feeling belongs with the internal life of the organism. Thinking, making use as it does of past observations and concerned as it largely is with planning for future action, belongs with observation and overt action in the life of external relations. Observation, thinking and acting differ from feeling in being more analytical, or intellectual, or brainy. The skillful handling of a well-observed situation is a brainier activity than merely feeling pleased or hopeful or discouraged. This brainy life of relation dominates at certain moments, and pushes the feeling of internal condition away into the background. At other times, the life of relation loses its grip or takes a rest, and feeling comes to the front.

Feeling is both sensory and motor. On the sensory side, it is the sensation-mass, unanalyzed and not utilized to indicate facts. On the motor side, it is the general set or attitude of the organism. Pleasure is a general set for keeping the situation as it is, displeasure for changing or getting rid of the situation. Excitement is a general readiness for great activity. Expectancy is the general set or readiness for something to happen.

Sources of pleasure and displeasure (*21*). Given the fact that some stimuli are naturally pleasant—sweet tastes and odors, gentle warmth, and some sounds and colors—and others naturally unpleasant, we might imagine that all other likes and dislikes were acquired by a process of conditioning or association. The Irishman likes green or orange according to the part of Ireland from which he hails, i.e., according to the conditioning to which he has been exposed. The swastika is a much more beautiful form to certain people than to certain others. Many likes and dislikes can be explained in this way, but not all of them.

Let us notice first that the agreeable taste or odor typifies only one of two great classes of things that naturally give us pleasure. Some things are pleasant without regard to any already awakened desire, while other things are pleasant only

when we want them. Unpleasant things fall into two similar classes. A sweet taste is pleasant even when we were not anticipating or desiring it at the moment, and a bitter taste is unpleasant though we were not trying to avoid it. A grating noise is unpleasant even when it comes as a surprise. In the other class belongs the pleasure of a cold drink when one is thirsty. One must first be thirsty to get this pleasure. The desire for water must first be aroused and then the water affords pleasure.

What is true of thirst is true of hunger or of any organic need. The need must first be present and then its satisfaction is pleasant. It gives you no pleasure to punch or kick a person or to swear at him, unless you are first angry at him. Let any drive be aroused, and then and not till then will the result at which the drive is aimed cause you pleasure.

The same can be said of desires that have been acquired through experience. At a football game, for example, when a player kicks the ball and it sails between the goal posts, half of the spectators yell with joy, while the other half groan in agony. Why should the sight of a ball sailing between two posts be so pleasant to some persons and unpleasant to others? This particular phenomenon is by itself neither pleasant nor unpleasant, but because the desire to see it happen is present in the partisans of one team, and just the opposite desire in the partisans of the other, therefore the pleasure or displeasure occurs. First arouse any desire, and then you can give pleasure by gratifying it, or displeasure by thwarting it. One sure way of giving a person pleasure is to start by awakening in him a desire for what you are prepared to give him.

This pleasure in receiving what one eagerly desires is not a conditioned response. The desire is learned or built up in experience, but the pleasure in getting what is desired is a natural reaction. Human nature is such that we are pleased when we obtain anything we happen to want. We are pleased also when we surmount an obstacle or when we reach safety after a flight from danger (p. 388).

In the preceding chapter, the various wishes of the indi-

vidual were grouped under three heads which were named the demand for security, the demand for pleasure, and the demand for achievement. The demand for pleasure calls for the good things of life, the demand for security seeks to avoid the dangers and hardships of life, and the demand for achievement is a zest for overcoming obstacles. Satisfaction of any of these demands gives pleasure, though the pleasure of security is rather tame unless the danger recurs or is imagined to recur. Since achievement also brings pleasure, why not reduce all three demands to one demand for pleasure and regard this as the sum and substance of all demands? Such an argument is often advanced. But to have the joy of achievement you must first achieve, and you are not going to achieve much if your desire is fixed on the expected joy. Your energies have to be concentrated on the problem in hand. Absorbed in the problem you plow through to success and then, almost as a surprise, comes the joy of achievement.

Both pleasures and displeasures are manifolded by memory and anticipation. A good time is enjoyed both in prospect and in retrospect. The same can be done for a bad time, but the normal tendency is to forget it and not to look forward to any more such times. The optimist, indeed, must often be reminded to "hope for the best and prepare for the worst."

No one has attempted to make an inventory of all the common experiences that give pleasure, but such a list has been assembled for annoyances, and the length of the list is surprising (*10*). A small sample of the most annoying common experiences is given here.

Annoyances

A person continually arguing
" " continually criticizing
" " monopolizing the conversation
" " bragging
" " bullying a child
" " always talking about his illnesses

A person assuming superiority
" " continually giving me unsolicited advice
" " interrupting when I am talking
" " paying no attention to what I say
" " prying into my affairs
" " nagging at me
" " trying to sell me something I don't want
" " crowding ahead of me in line
" " late for an engagement
" " swearing
" " spitting, belching, stuffing his mouth, picking his nose, etc.
Untidy room, clothes, hands, etc.
A mosquito buzzing when I want to sleep
Cats howling at night
A window rattling
False teeth

Hundreds of other annoyances have been reported. Some of them seem quite innocuous and may be instances of conditioned responses, originating in some unpleasant situation or by association with something that was genuinely unpleasant. Many varieties of annoying behavior suggest that the person so behaving feels himself superior or lacks consideration for others. Even when he is merely breaking an unnecessary social taboo his behavior suggests that he does not care what other people think. When a person behaves in any such way he offends your own desire for superiority or at least equality, and so causes a feeling of annoyance. Apparently this is one great source of unpleasantness in social life. When asked to think of people they most like and dislike and to say why in each case, college students mention a large number of traits, but the most frequently mentioned on the undesirable side are conceitedness and deceitfulness. On the desirable side, most often mentioned are intelligence and cheerfulness (*19*).

EMOTION

Emotion is a "moved" or stirred-up state of the organism. It is a stirred-up state of feeling—that is the way it appears to the individual himself. It is a disturbed muscular and glandular activity—that is the way it appears to an external observer, who sees the clenched fists and flushed face of anger and the tears of grief, or who hears the loud laugh of merriment and the pleading tones of love.

Each emotion can be located in the tridimensional scheme of feeling, but such an analysis does not do full justice to the emotion. Fear is a state of excited, unpleasant expectancy, and mirth is excited, pleasant relief, but each is something more. Each emotion is a sensation-mass, and each is at the same time a motor set. Fear is a set for escape, and anger for attack. Mirth is a readiness to laugh, and grief a readiness to cry. These sets are more specific than the accepting and rejecting sets characteristic of mere pleasantness and unpleasantness.

How emotions are defined and distinguished one from another. Though we all know the emotions as matters of personal experience, no one seems to be able to describe them adequately either as subjective feelings or as muscular and glandular activities. How, then, can we tell the emotions apart? How does it come about that we have that large vocabulary of names of different emotions? The several emotions are distinguished, in practice, by stating the *external situation* in which each occurs and the type of *overt response* demanded. "The various emotions can be readily identified and defined only in terms of the behavior situations in which they occur" (*9*).

Fear is the emotional response to danger; anger, to interference; joy, to success; surprise, to any unexpected happening; mirth is the emotion that goes with laughing; grief, with sobbing; and so on. Any particular emotion is the stirred-up state appropriate to a certain situation and overt response.

It is true that the situation and overt response may occur

without emotion. You may fight off an attack without anger, or dodge an automobile without fear. If the overt response is prompt and successful, emotion may not be aroused. If the brainy life of relation dominates the organism at the moment, the emotional response is minimized. But if the situation gets out of hand, the emotion appropriate to the situation surges up. From the situation and overt response, then, you cannot safely assert that the individual is undergoing an emotion; but you are reasonably sure that, if he is undergoing an emotion, it is the one that usually goes with that situation and that response.

How emotions are revealed—expressive movements. Smiling, laughing, scowling, pouting, sneering, sobbing, screaming, shouting and dancing up and down accomplish no important external result, except for their effects on other people. What is the sense of these movements? At first thought, the question itself is senseless, the movements are so much a matter of course, while on second thought they certainly do seem queer. What sense is there in protruding the lips when sulky, or in drawing up the corners of the mouth and showing the canine teeth in contempt? Darwin, after studying these movements in men and animals, suggested that they were *survivals* of acts that were once of practical utility in the life of the individual or of the race.

Shaking the head from side to side, in negation or unwillingness, dates back to the nursing period of the individual, when this movement was made in rejecting undesired food. The nasal expression in disgust was originally a defensive movement against bad odors; and the set lips of determination went primarily with the set glottis and rigid chest that are useful in muscular effort (p. 383). Such movements, directly useful in certain simple situations, become linked up with similar but more complex situations in the course of the individual's experience.

Showing the teeth in scorn dates back, according to Darwin, to a prehuman stage of development, and is a useful act in animals like the dog or gorilla that have large canine teeth. Baring the teeth in these animals is a preparation for using

the teeth; and often it frightens the enemy away and makes actual attack unnecessary. This movement, Darwin urges, has survived in the race even after fighting with the teeth has mostly gone out. Many other expressive movements can be traced back in a similar way, though it must be admitted that the racial survivals are usually less convincing than those from the infancy of the individual.

Learning to control emotional expression. Some expressive movements, like smiling, laughing, crying, sobbing and screaming, are certainly unlearned; others are picked up by imitation. All expressive movements become attached or conditioned to situations that originally could not arouse them. As the child grows up, he learns to *moderate* his expressions of anger and of glee, and he even learns to *conceal his emotions.* He is ridiculed for crying or showing fear; he gives offense by showing anger, or by crowing and strutting in pride. Politeness requires him to smile many times when he feels like scowling, and to exclaim in surprise at information that is perfectly trite. Thus social pressure trains him to keep his feelings to himself. At the same time, other people are always trying to discover how he does feel, and he himself scans the faces of other people in the attempt to *read their emotions.* There is a race between concealment of the emotions on one side and detection of the emotions on the other, like the naval race between defensive armor and penetrating projectiles.

On the whole, expressive movements tend to become reduced as the individual grows older. But in make-believe play and on the stage there is a development in the opposite direction, in the direction of *depicting the emotions.* There is a language of the emotions, composed of gestures and postures, of exclamations and inflections and tones of the voice, of facial expressions. This language is no doubt based upon the unlearned expressive movements, but it has become standardized through long ages, and now is largely a matter of social custom and convention. The child finds this language in use, and appropriates it to some extent. Actors appropriate it to a large extent, and introduce their own indi-

vidual improvements. The result is that this language of the emotions is much more expressive than the average adult's facial and vocal behavior during emotion. When the actor

A B

FIG. 69.—(Feleky, *12.*) Two poses, A being intended for surprise and B for hate. When shown to 100 persons they got a variety of judgments as shown by the following counts, and still most of the judgments of the same pose are rather similar.

Pose A		*Pose B*		*Pose B—Continued*	
surprise	52	ugliness	13	disregard	1
wonder	12	disgust	11	bore	1
astonishment	11	hate	8	fury	1
amazement	9	disdain	8	sulkiness	1
admiration	3	scorn	7	pouting	1
awe	2	defiance	6	pettiness	1
dismay	2	aversion	5	disagreeable	1
playful interest	1	repugnance	5	suspicion	1
earnestness	1	bitterness	3	self-assertion	1
enthusiasm	1	contempt	3	self-sufficiency	1
rapture	1	loathing	3	displeasure	1
hope	1	irritation	2	perturbance	1
romantic love	1	hardness	2	weeping	1
friendliness	1	sneering	2	timidity	1
altruistic pride	1	dislike	2	pain	1
repugnance	1	antipathy	1	mental pain	1
		sullen anger	1	disgusted dread	1
				sorrowful pity	1

poses for an emotion, he makes full use of his face; but when the ordinary citizen is in an emotional state, his face is little more than a mask.

How expressive is the facial language of the emotions? To obtain evidence on this question—obviously an important question for social psychology—the experimenter presents

photographed facial poses and asks you to judge what emotion is portrayed by each pose. The words used by different observers to characterize a given pose vary considerably and

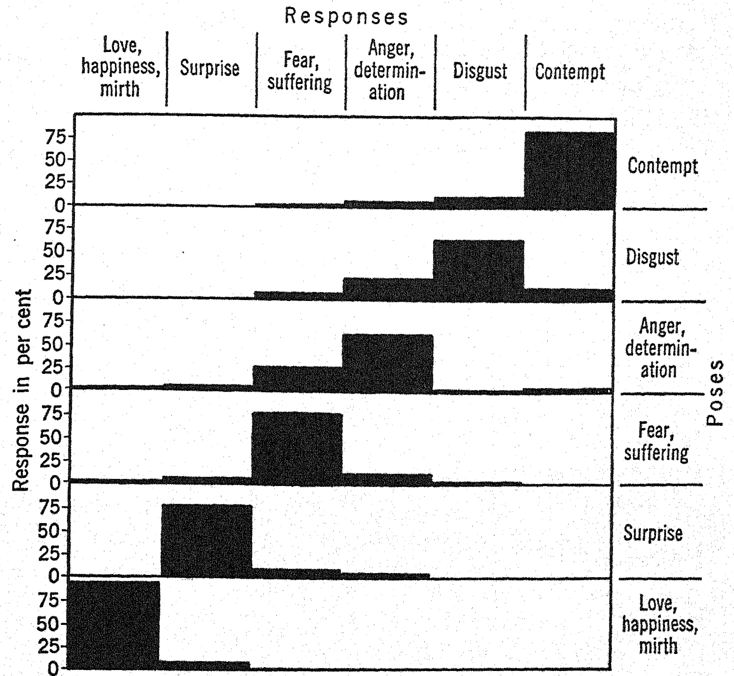

FIG. 70.—(Data from Feleky, *12*.) Judgments of posed facial expressions, showing general agreement with the actress's intentions. There were 100 judges, and 6 emotions (or classes of emotions) depicted. For each emotion a distribution curve of the judgments is shown. Reading along the bottom line we see that the poses for "love, happiness or mirth" were judged to represent one of these same emotions by about 90 percent of the subjects, the remainder judging "surprise." Reading across the top line we see that the poses for "contempt" were never interpreted to mean love, etc., nor surprise, and only rarely to mean fear or anger, etc.; more often disgust but usually contempt, as intended by the actress. The oblique slant of the whole diagram indicates a fairly high positive correlation between the intentions and the judgments.

at first thought indicate that emotion cannot be read from the face alone. More careful study of the judgments, however, shows that the errors committed are relatively small. A pose for love will often be called "happiness" but never "contempt." It is possible to arrange a scale of emotions

from love at one end to contempt at the other, with anger about in the middle, and to distribute along this scale the judgments passed on each pose. The distribution shows the judgments for each pose concentrated about a center at or near the intended emotion. There is on the whole a very good correlation between the pose and the judgments. Though the finer shades of emotion are not very successfully conveyed by the face, the general character of the emotion is well depicted. If so much as this can be done with still photographs of the face alone, the living actor, with posture and gestures visible as well as the face, would certainly convey the intended emotion very completely.

Emotional attitudes can be expressed by the hands, and a few gestures have been conventionalized and are readily understood. Everyone knows how to express by his hands an inclination to fight, to accept, to reject or to plead for mercy. Experiment shows that an actor will undertake to portray a large number of emotions by the hands alone and that college students, viewing photographs of the poses, are in fair agreement on a number of them. The agreement is somewhat better when motion pictures of the actor's manual poses are used instead of the still views. The observers in this experiment testify, as they do also in experiments in the interpretation of facial expressions, that they use two devices to assist them. They imitate the pose to see how it feels; or they imagine a situation in which the given expression would be appropriate (*8*).

Unposed facial expression. Photographs of the spontaneous expressions of unhistrionic adults in the throes of genuine emotion are not easily obtained. In the psychological laboratory, strangely enough, more success has been achieved in arousing unpleasant than pleasant emotions.

In one experiment (*14*), lasting over three hours, a series of situations was presented for the purpose of arousing a variety of emotions, the series beginning with music and serious reading, and proceeding to startling, embarrassing, disgusting and painful situations, which became so drastic at the close as to cause weeping or vigorous angry language

from nearly all the subjects. An attempt was made to analyze the facial expressions in terms of the different muscles concerned—those that raise or lower the brow, those that widen or narrow the eyes, those that "stick up" the nose, those that pull the lips upwards, outwards or downwards, etc. The object was to see whether there were any patterns of facial movement characteristic of the different emotions, but the results were rather negative. One individual differed from another in his characteristic expression; but the different situations failed to produce any strikingly different facial expressions. The eyes were apt to be narrowed in most of the situations, and the mouth was apt to be drawn into some sort of a smile or half smile—a sort of "grin and bear it" expression. There was more concealment than free expression.

Vocal expression of emotion. The voice is perhaps more expressive than the face. The speaking voice is more expressive than the singing voice, because it takes on a harsh quality when required, and because it is free to slide up and down the pitch scale. The rising inflection in questioning, the fall-

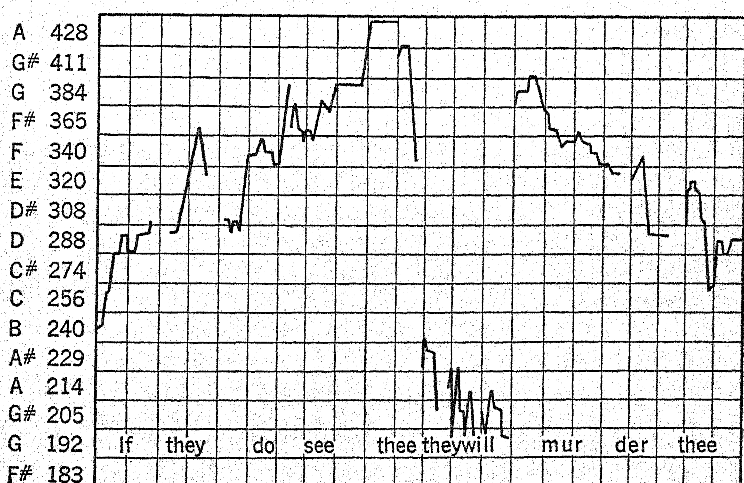

FIG. 71.—(Merry, *16*.) Inflection of the voice in emotional speaking. When the curve goes up the voice rose in pitch. Measured from a phonograph record of Julia Marlowe's rendering of Portia's speech in "The Merchant of Venice."

ing inflection in finality, the circumflex inflection in sarcasm, are very expressive. The little word, "No," can be made to carry several meanings according to the inflection. Monotone goes with dull feeling, slides and jumps from low to high and from high to low go with excitement. The connection of excitement with loud and high-pitched voice is probably natural and unlearned, but how much more of the language of voice, apart from speech, is unlearned and how much is dependent on social custom, we can only guess at the present time. When words, with their associated meanings, are added to vocal tones and inflections, the emotional expression becomes clear and finely shaded. Just the printed word, HORROR, in a newspaper headline, creates an emotional atmosphere.

Breathing and heart beat in emotion. Excitement, attended as it is apt to be with muscular activity, calls for increased breathing and heart action. A startling noise checks breathing and first stops and then hastens the heart. Breathing is shallow during a brief period of concentrated attention, and at the end of such a period there often appears a deep inspiration followed by a rather forcible expiration. This "sigh" makes up for the insufficient respiration of the preceding period. The sigh of grief or longing may perhaps arise in the same physiological manner.

The chest movements in breathing can easily be recorded by suitable apparatus, and various peculiarities of the movement pattern are found in emotional states. Laughing and sobbing give very peculiar breathing curves. A few psychologists, after becoming expert in the analysis of breathing curves, have attempted to detect a subject's emotional state from his breathing record. They have been especially interested to see whether they could detect the suppressed excitement incident to giving false testimony before a court or inquisitor. In an experimental setup, the subject is instructed to give true or false testimony before a group of persons, and this "jury" attempts to decide whether the witness is lying or telling the truth. Meanwhile his breathing record is taken,

and from the record the experimenter attempts to reach a decision on the same question. With a fairly competent liar in the stand, the jury has only a 50-50 chance of guessing right, but some experimenters have scored almost 100 percent by analysis of the breathing record. On the whole, however, the method is not as successful as the one described just below.

The *blood pressure*, or pressure in the arteries, depends on complex physiological factors, the chief of which are the output of blood from the heart, and the resistance offered by the small arteries to the passage of blood. In the lying experiment, the blood pressure rises in about 80 percent of the cases. Possibly this indicator of deception could be used in the police examination of suspects; and indeed the method has been used with some success, but is still in the experimental stage. There is no mysterious connection of lying with blood pressure or with breathing. The blood pressure is apt to rise in excitement, whether the excitement is brought on by the exigencies of making up a plausible story, by taking an intelligence test, by watching a "sexy" motion picture, or by receiving strong electric shocks. In the prolonged emotional experiment described a few pages back, the blood pressure rose towards the close of the series of disturbing situations. It also rose momentarily in surprise.

Other signs of emotion. The cat's hair rises in fear or anger, and goose flesh in the human being is the same response, produced by tiny muscles under the control of the so-called "sympathetic" nerves. The pupil of the eye dilates in the same conditions, from the action of another, related nerve. The sweat glands are similarly aroused, and in strong emotion the perspiration may stand in beads upon the skin. Even in momentary thrills of fear, surprise, embarrassment or expectancy, the sweat glands are stimulated to a slight degree by their nerves, and the result is a momentary change in the electrical condition of the skin, which can be registered by a galvanometer and is called the *psychogalvanic reflex*. This electrical change is a delicate indicator of ac-

tivity in the "autonomic nerves" which are the next thing to be considered.

ORGANIC STATES IN EMOTION

Traditionally, the heart is the seat of the emotions, and this means, no doubt, that they are felt in the general region of the heart; and other ancient "seats," in the diaphragm or in the bowels, agree to the extent of pointing to the interior of the trunk as the general location where emotions are felt. There may be something in this primitive location of the emotions; there may be some internal disturbance in strong emotion that makes itself felt by obscure sensations.

To understand what goes on in the interior of the trunk, we need to add to our previous information on the endocrine glands (p. 170) some knowledge of the nerve supply of this region.

The autonomic nerves. These are the nerves that run to the heart, blood vessels, lungs, stomach, intestines and other viscera, and also to the sweat glands, the little muscles of the hairs, and the iris of the eye. They run, that is, to the "smooth muscle," a slower-acting, but more automatic type of muscle than that of the limbs, and they run also to glands. These nerves are composed of extra-slender nerve fibers, which grow out from cells in the brain stem and cord, and so are part of the general nervous system, not a separate system as was formerly believed. There are three divisions of the autonomic, upper, middle and lower. The *upper division* grows out from the brain stem, and, among other effects, slows the heart beat, but stimulates the glands of the stomach to pour out the gastric juice, and the muscular wall of the stomach to make its churning movement. Thus the upper autonomic is active in digestion. The *middle division* of the autonomic consists of the "sympathetic" nerves, which come out from the spinal cord at the level of the chest, and which have the opposite effects on the heart and stomach to those of the upper division. The sympathetic hastens the heart, raises the blood pressure, retards or checks stomach activity,

and has the other effects just described as "signs of emotion" (p. 425). The sympathetic in its wide distribution also overlaps the *lower division* of the autonomic (which comes from the lower part of the spinal cord), and it antagonizes the latter's stimulating effects on the genital and excretory organs.

There is a brain center for the autonomic system in the hypothalamus, a part of the interbrain (pp. 265, 273). This fact becomes the more interesting when we learn that many students of the brain are convinced that the interbrain plays an important part in feeling and emotion. Indirectly, the autonomic is influenced by the cerebral cortex, as we see from the fact that something you merely *think* of may hasten or slow the heart, make you blush or turn pale, and promote or disturb your digestion.

The organic state in anger. Suppose we have a cat that knows us well, and after feeding her a good meal containing some substance that is opaque to the X-rays, suppose we place her on a table and pass X-rays through her body, so as to get a visible shadow of the stomach upon the plate of the X-ray machine. Well and good; the cat is contentedly digesting her meal, and the X-ray picture shows her stomach to be making rhythmical churning movements. In comes a fox terrier and barks fiercely at the cat; she shows the usual feline signs of anger but is held in position and her stomach kept under observation—when, to our surprise, the stomach movements abruptly cease, not to begin again till the dog has been gone for about fifteen minutes. The churning movements of the intestine cease along with those of the stomach, and, as other experiments show, the gastric juice stops flowing into the stomach. The whole business of digestion halts during the state of anger. So anger is an organic state, without doubt. In man also it is an excellent rule not to get angry on a full stomach (*4*).

Stomach inhibition is not the only internal response during anger. The heart beats more forcibly than usual. The medulla of the adrenal glands (p. 425) is aroused by the sympathetic nerves and discharges its hormone into the circulation. The adrenin reinforces and prolongs the changes pro-

duced by the sympathetic nerves in the stomach, heart, blood vessels and other organs.

The sympathetic-adrenal organic state as a useful preparatory reaction. Apparently the internal condition in fear of the energetic type is the same as in anger. This organic state, though useless and perhaps a handicap in most of the activities of civilized man, does make a first-class preparation for intense muscular activity, such as is demanded by physical flight or combat. Rapid circulation and abundant fuel are demanded, while digestion can wait till the emergency is past.

Essentially the same organic state can be detected, physiologically, in strenuous muscular activity such as running a race. It has been found in football players before a game, and in students just before an examination. Probably the organic state was useful to the football players, and far from useful to the students. In both cases the emotion was scarcely fear or anger; the subjects said they felt "all on edge" or "all keyed up." It was, in a word, a state of *excitement*.

Excitement, as already suggested, is a readiness for great activity—not for any special kind of activity but for whatever activity is on foot. Probably there are two kinds of excitement: the tense, fidgety, shivery kind, when one is eager to get started and is only waiting for the time to arrive; and the hot, hyperkinetic kind, when one is in the thick of action. Athletes awaiting a contest are well aware of the tense, expectant kind, which may make itself felt a day or more before the contest and increase till the event actually starts, giving way then to the state of intense overt activity. The latter state does not appear emotional to the subject because he is thoroughly absorbed in the game, i.e., in the objective situation and the results accomplished or attempted. The two states are seen also in the public speaker while waiting his turn, and while successfully making his speech. Possibly there are two somewhat different organic states of excitement, the shivery state being a one-sided sympathetic-adrenal affair, and the hot state being pro-

duced by a more balanced activity of the autonomic nerves (*13, 18*).

Pure excitement is neither angry nor afraid. Angry feeling is excited feeling, to be sure, but it has its own special impulsive quality which is different from the impulse of fear. These impulses are directed toward overt activity: toward attack in anger, toward escape in fear. In anger and fear, then, we find (a) a set of the organism toward certain types of overt activity, and (b) an organic state which is a physiological preparation for those types of activity. The set for the special overt activity, occurring alone, would be felt simply as an impulse to attack or escape. The organic state, occurring alone, would be felt as excitement. The combination of set and organic state is experienced as an emotion of anger or of fear.

The foregoing analysis of anger and fear raises the question whether a similar analysis would hold good of other emotions. Is each emotion a set for some type of overt behavior, combined with an appropriate organic state? The set would of course be different in each emotion, and the organic state would probably differ from one emotion to another. But the set-state pattern might be present in every emotion. Is it so?

Organic states in other emotions. Can we find similar combinations of particular organic states with particular sets for overt activity, and can we regard emotions generally as made up after the model of anger? The studies already cited of sex appetite show a similar pattern (p. 176). There is a set for overt sex behavior, and there is an organic state which is not the same as in anger or fear though it does involve excitement.

This same pattern is present in hunger and appetite for food. There is the organic state of food-depletion, with stomach movements and readiness of the salivary and gastric glands for active secretion, and there is the set of the organism for the overt behavior of food-getting and eating. Hunger, to be sure, is not usually called an emotion, but rather just an organic state and sensation, largely because

the hunger pangs are localized as coming from the stomach region and are noted as indicators of the fact of organic hunger. But if the hunger sensations are not very intense, they may not be definitely localized, and the individual may simply feel an appetite for food, which certainly should be classed as an emotion.

Fatigue from muscular activity is an organic state consisting largely in the accumulation in the muscles and in the blood of the waste products of muscular action, especially carbon dioxide and lactic acid. These substances, carried about by the blood, lower the activity of the organs through which they circulate. There may be local fatigue sensations in the exercised muscles and joints, and also a general diffuse weariness. There is clearly a set towards the overt behavior of resting. The organic state predisposes the organism for this type of behavior. Thus fatigue fits nicely into the pattern we are testing.

What may be the nature of the organic state in drowsiness we cannot say, but there surely is an organic state, and it predisposes for sleep. If we allow ourselves to regard sleep as a form of overt behavior, then our scheme works all right here again. And it works with thirst as well, though the sensation of thirst is so well localized that we do not call it an emotion.

Emotions without known organic states. Several of the best-known emotions do not fit neatly into the scheme suggested by anger, because their organic states, if any, are not known.

Surprise is allied to fear. The psychogalvanic reflex, which is an indicator of the activity of the sympathetic nerves, is readily aroused by surprising stimuli. In surprise, the activity in progress is brought to a sudden halt, and the organism attends to something new and possibly dangerous that has entered the situation. The internal response is a slight beginning of the activity that goes with danger. The overt activity is a slight beginning of escape. Surprise, then, does show an organic state combined with a set for a certain activity, and so is no real exception to our rule.

Mirth or amusement is the emotion that goes with laughter. Is there possibly an organic state here? All we can say is that laughter favors digestion, removes anger and counteracts fear—facts suggestive of some organic process opposed to that of anger and fear.

Grief, if we may so call the emotion that goes with the baby's crying, is like mirth in having no known organic state.

Joy, though akin to mirth, often occurs in situations that would not be called amusing. It would be going too far to assert that joy has no organic state; it would be going just far enough to say that we do not know.

In *curiosity*, though the feeling is often strong enough and different from any of the other emotions, it would seem improbable that there is any special organic state. The overt activity consists in exploring what has aroused curiosity.

All in all, this brief survey of emotions shows them all possibly but not certainly fitting into the scheme suggested by anger. There is always a set for some overt activity, and almost always there is the possibility of an organic state.

Moods. A mood differs from an emotion in being less in intensity and longer in duration. While in an angry mood, a person may not be actually angry, but he is all ready to be made angry by the least provocation. Such a mood is often a hang-over from an active emotion. Let a man be "all riled up" by something that has happened at the office, and he comes home quite ready to take it out on his wife and children. Slightly irritating performances of the children, that usually would not arouse an angry response from him, do so this evening because that thing at the office has made him cross. In the same way, a nervous or jumpy mood may follow a dangerous experience. From the fact that the cat, in the X-ray experiment, showed the internal state characteristic of fear and anger for quite a while after the irritating dog had gone away, we may conclude that angry and timorous moods are due, in part at least, to the persistence of the organic state set up in active emotion.

But what shall we say, then, of the persistence of a jovial mood after a good laugh, or of a happy mood after the joy

of success? Perhaps there is an organic state, here too, that outlasts the active emotion.

Not every mood, however, is an after-effect of an active emotional outburst. Euphoria seems to be the mood that goes with excellent physical condition, and a depressed or "blue" mood may mean simply an unfavorable physical condition. Lassitude and the morning grouch may be simply the mood of one who is not yet fully awake.

Development of the emotional life. Undoubtedly the emotional life of the child develops by maturation as well as by learning. Sex emotion cannot fully make its appearance till sex maturity brings the hormones and organic states that are essential to the emotion. The child's fears increase and later decrease partly because of conditioning and other processes of learning, but partly because his increasing intellectual maturity enables him to see dangers of which the baby is wholly unaware, and later enables him to see the harmlessness of things he had previously feared (pp. 379-380). The same is true of annoyances. The child learns to substitute laughter for fear or anger in many situations. He learns also to moderate his crying and other free expressions of emotion. The practical life of relation dominates more and more over the emotional life, so that the child's behavior becomes less emotional as he grows older. A scale for emotional age, after the analogy of the Binet scale for mental age, would consist in large part of tests for *not* being afraid or angry or grieved or inquisitive over things which regularly arouse these emotions in the younger child.

Emotional development goes hand in hand with the development of attitudes and sentiments (p. 392). The higher emotions, social, religious and aesthetic, probably do not bring in any new organic states. They are essentially sentiments, attitudes tinged with emotion, built up in the individual's experience, largely as the result of social influences.

THEORY OF THE EMOTIONS

Our final task in this chapter is to put together the main facts that have emerged from our study of feeling and emotion, with the object of discovering (a) the difference between emotional behavior and unemotional, and (b) the difference between one emotion and another.

The main facts we have to work with are:

1. The situation in which the individual is placed, and his intellectual perception of the situation.

2. His set for a certain overt activity or for a certain result, such as escape from danger.

3. The organic state, present in some emotions, though perhaps not in all, this state not being the same for all emotions, nor yet different for every different emotion; it appears to be the same in anger, fear and other excited states, but something else in sex appetite or in food appetite or in fatigue. The organic state depends largely on the autonomic nerves and their center in the interbrain.

4. The sensations produced by the internal organic activity, by expressive movements, and by the overt activity, these sensations being felt as a mass.

5. The greater or less dominance of the organism by the practical or brainy life of relation as against the more diffuse and undirected type of activity which occurs in strong feeling and emotion.

The James-Lange theory of the emotions. The American psychologist James, and the Danish physiologist Lange, independently of each other, put forward this theory about 1880, and it has ever since remained a great topic for discussion. According to the theory, a conscious emotion is simply a mass of sensations from all over the body, especially from the internal organs. The emotion is the *way the body feels* when in a disturbed organic state, and when going through the expressive and overt movements characteristic of the emotion.

James says, we do not tremble because we are afraid, but are afraid because we tremble. He means that the conscious

state of fear is composed of the sensations of trembling (along with the sensations of other muscular and glandular responses). He means that the mere knowledge of present danger is not a feeling of fear, and that the feeling only comes with the organic and overt response. As soon as these responses take place, they produce a mass of disturbed sensation, and then the feeling of fear wells up. "Without the bodily states," James says, we might "see the bear, and judge it best to run, receive the insult, and deem it right to strike, but we should not actually *feel* afraid or angry." The "emotional warmth" of the experience comes from bodily sensations.

In appraising the value of this theory, we have to consider what theory it was intended to supplant. It was aimed at the common-sense theory which supposes that the sight of the bear arouses the feeling of fear, and that this feeling gives rise to the organic state and to the overt movements of escape. The James-Lange theory holds, on the contrary, that the organic state precedes the feeling and gives rise to it; and that therefore the feeling would be impossible without the organic state. What arouses the organic state, according to the theory, is the intellectual perception of danger, not the feeling of fear; the feeling arises from the organic state.

Evidence against the James-Lange theory. Sherrington attempted a physiological examination of this question (*17*). Having a dog in the laboratory that showed a markedly emotional temperament, affectionate toward some individuals and hostile to others, he performed certain nerve-cutting operations which deprived the animal of nearly all sensation from the interior of the trunk. This loss of sensation produced no obvious change in the dog's emotional behavior. "Her anger, her joy, her disgust, and when provocation arose, her fear, remained as evident as ever." A visitor who had previously awakened her anger was again received with signs of rage—wide-open eyes, dilated pupils, vicious growls—while the attendant who fed her was received with all signs of joy.

This experiment certainly proves that the overt behavior and expressive movements of emotion do not depend upon sensations from the interior of the trunk. Of course, it is impossible to say, absolutely, what the dog *felt*. It might be argued that the dog went through the external movements with no emotional feeling. But so strained an interpretation of the dog's behavior could only be justified by very strong evidence from some other source of the truth of the James-Lange theory.

Another physiological experiment carries us a step further. The sympathetic nerves of a cat were severed, and the whole organic state of anger, dependent on those nerves, was made impossible, and still the cat continued to show the overt behavior and expressive movements of anger—growling, hissing, showing the teeth, drawing back the ears, lifting the front leg to strike. So far as we can judge from an animal's behavior, the organic state is not an essential part or factor in the emotion of anger (*5*).

For sure evidence on the subjective feeling in emotion, we need testimony from human subjects. One important case bearing on the problem is that of an intelligent woman of forty whose neck was broken by a fall from her horse. The breaking of the spinal cord in the neck interrupted all the sensory and motor nerve pathways between the brain and the trunk and limbs, except for the connections by way of the upper division of the autonomic with some of the internal organs. The sympathetic or middle division was entirely disconnected from the brain, and all sensations from the trunk and limbs were abolished. According to the James-Lange theory, practically all emotional experience should have been abolished; yet, during the year that the patient survived the accident, the expert neurologist who attended her reported that he "saw her showing emotions of grief, joy, displeasure and affection. There was no change in her personality or character." We should have more cases, but this one certainly indicates that emotional experience can arise in the brain without the help of sensations from the body and limbs. If the emotional experience is not a mass of sensa-

tions, what can it be? Probably it is simply the experience of behaving in a certain way, i.e., of letting oneself go in the direction of a certain impulse or attitude (*11*).

What would happen if the organic state characteristic of fear and anger could be artificially produced, without any external cause for fear or anger? This experiment has been tried, by giving adrenin to human subjects—under medical advice, as an overdose has bad effects. Definite physical symptoms are produced, such as rapid pulse, cold hands and feet, trembling of the arms, legs and voice. The subjects commonly report that they feel nervous, uneasy, tense, excited, or "on edge," as before a game or race in which they are to take an active part. Many of the subjects go a little further and say they feel "as if anticipating an emergency of some sort," or "as if they were awaiting a great joy," or "as if they were going to weep without knowing why." These subjects admit having an "as if" emotion, but not a true emotion. They say they have some of the feeling of fear, but no real fear because there is no cause for fear. In a few instances a "vague, nameless fear" is reported, and very rarely a gust of genuine though still causeless fear. In most cases, it appears, the subject in this experiment keeps his head and is not really frightened, knowing he has nothing to fear. But while under the influence of the adrenin he is more easily frightened than in the normal state (*6*, 7).

In an experiment of quite a different type, the blindfolded subject was seated in a mechanical chair which was suddenly tilted backward into a horizontal position. Apparatus registered his breathing and heartbeat which were much disturbed. The subject made a movement to save himself and experienced the feeling of fright. He returned on another day and was seated in the same chair. As he now anticipated the sudden drop he took it without any overt movement to save himself, but his heart and respiration again betrayed some internal disturbance though less than on the first day. The subject reported that he did not experience fear on this second occasion. Here we have the organic state of fear, occurring when the subject was so well adjusted to the

situation that he made no overt escape movement; and the feeling of fear was absent. About twenty subjects gave concordant results (*3*).

The upshot of all the experimental evidence seems to be that an organic state, while predisposing the individual to a certain emotion, is neither necessary nor sufficient for the emergence of emotional feeling and behavior. Under ordinary conditions, to be sure, a certain organic state is present in fear and anger, and it doubtless contributes to the frightened or angry state. As the same organic state occurs in both fear and anger, the difference between these two emotions must lie in the set for escape in one and for attack in the other. And this same organic state occurs in excitement that is neither frightened nor angry. A sprinter probably has the same organic state as a man who is fleeing in terror, and gets the same sensations from the internal organs and from the running muscles. He ought, then, according to the James-Lange theory, to have the same frightened feeling. The theory certainly breaks down here (*5*).

The difference between emotional and unemotional activity does not lie in the presence or absence of an organic state, nor in the presence or absence of a certain overt activity, nor in the presence or absence of certain sensations. It depends on the degree to which the individual keeps his head, that is, on the degree to which the brainy life of relation dominates his whole activity. If he completely loses his head, his sensations become a diffuse mass of feeling, and his set for overt activity becomes a blind struggle.

Under what conditions is the individual likely to lose his head? When does the brainy life of relation relax its grip and leave emotion unfettered? When the situation cannot be handled successfully. When the goal cannot be reached quickly enough. When the goal has been reached, and there is nothing to do but to burst forth in joy. When the organic state is strong and lively, like a horse that is all warmed up and hard to control. During intoxication, when the cerebral cortex, concerned in the "brainy life of relation," ceases to dominate the lower parts of the brain (largely, perhaps, parts

of the interbrain) which, when left to themselves, carry out the blinder and more impulsive life of emotion (*1*, *15*).

We have been speaking too much in antithetical terms, as if the individual at any moment must be either in a storm of emotion or else in a state of perfect calm. Actually there are all degrees of emotion, and a moderate degree does not prevent the individual from using his head. A perfectly cold intellectual activity, free from any tinge of emotion, may never occur. If you are engaged in an activity that bores you, that boredom has an emotional quality; and if the activity interests you, the interest, too, partakes of emotion. If an activity neither bores nor interests you it is probably going on automatically, leaving you free to think of something that does have interest. Usually the intellectual and the emotional are harmoniously combined in the total activity. The cortex and the lower brain centers usually work together in harmony, with the cortex dominating but not suppressing the lower centers.

Conclusion. We set out to find the difference between emotional and unemotional activity, and the difference between one emotion and another. In typical strong emotions there is normally present some organic state, directly under the control of the autonomic nerves and of their center in the interbrain. It appears that the peripheral organic state is not altogether necessary for the emotion to arise, provided the interbrain or other lower brain center is working. The degree of emotionality depends on how free the lower centers are at any time from domination by the cerebral cortex. Or, if we do not pin our faith to any particular theory of the brain action, we can say that activity is unemotional in proportion as it consists in observing and managing the situation.

Besides the organic state there is present in feeling and emotion a set or attitude of the individual. The set differs from emotion to emotion and provides the most definite difference between them. Besides, there are several organic states, though not as many as there are emotions. The difference between emotions, then, depends primarily on the

attitudinal difference and secondarily on certain differences in the organic state.

Summary of the chapter. Pleasantness and unpleasantness are conscious states of the organism, consisting apparently of unanalyzed masses of sensation along with a set for acceptance or rejection of the situation. Excitement is a bodily state with a feeling of readiness for energetic muscular activity. Pleasure and displeasure result sometimes from the mere presence of certain tastes, odors, tones or other stimuli, and sometimes from the satisfaction of an organic need like hunger or from the satisfaction of any active desire. In social situations displeasure results largely from the interference of other people with one's demand for superiority or at least equality. In many emotions, perhaps not in all, we see an organic state combined with a set for a certain goal—for escape in fear, for damage to the adversary in anger. The visceral state, much emphasized in some theories of the emotions, seems not to be essential for emotional behavior or feeling. Other theories stress the importance for emotion of the lower brain centers, especially the interbrain. When one is intensely interested in some practical or intellectual activity, the cortical and subcortical centers are working together in perfect balance. The emotions can be expressed to some extent by the face, the hands, the voice; more often they are concealed.

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Chapter XIII

Observation

THOUGH some complaints reach the consulting psychologist's ears about poor powers of observation, about failure to notice things that would have been quite important for the individual to know, more complaint is usually heard of the individual's poor memory. In studying memory, however, we came to the conclusion that poor memory means poor learning rather than poor retention, and that the best learning consists in noticing relationships, patterns and meanings and thus amounts to learning by observation. The individual who complains of poor memory must therefore, in most cases, be hampered by poor observation.

There are two steps in observation, which may be called 1 *attention* and 2 *perception*. Attention is preparatory to perception. Attention brings the observer into the presence of a fact, and perception consists in his grasping or knowing the fact. Attention explores, perception discovers. Columbus, first exploring westward, then discovering America, shows on a grand scale the same steps that are present in miniature whenever we first look towards something that has caught our eye and then see what is there.

Since "poor attention," as well as "poor memory," is a common complaint, this general topic of observation must be one of the most important in psychology from the practical standpoint. That impression is confirmed by reviewing the numerous references to observation that have been made in the previous chapters. With regard to attention, which was taken up very early to illustrate some general principles of psychology (pp. 43 ff.), the statement was made that, while

bright lights and other strong or striking stimuli would catch the attention, sustained attention could not be secured without appealing to some real interest of the individual. Inattention, except in a drowsy state, is attention to something else that is more interesting. To develop good powers of attention to a certain subject or line of activity, the prescription is to develop an eager interest in that subject. Some exploration is necessary before the interesting nature of the subject is fully revealed. It is the same with a person; you must get somewhat acquainted with him in order to know whether or not he is an interesting person. Interests and other attitudes are developed by exploring an object (in the broadest sense of "object") and discovering some of its characteristics. That is, the development of interests, attitudes, and all motives beyond the primitive drives depends on observation (pp. 392, 395).

In animal as well as human learning and problem solving, the evidence goes to show that observation plays an important part (p. 324). In Pavlov's experiment the dog became "impressed through the senses" (observation in its lowest terms) with the regular bell-food sequence characteristic of a certain laboratory situation. The rat in learning to run a maze starts with general exploration and gets acquainted with the maze as a place or "field of objects." Trial and error behavior, like that of the cat in the puzzle-box, amounts to manipulative exploration and reveals hidden characteristics of an object, which are learned by "hindsight." Sometimes a problem is mastered by foresight rather than hindsight, both types of insight belonging evidently under the head of observation.

The reason for this central importance of observation is clear when we consider the individual's relations with the environment. Through his receptors he receives stimuli from the environment, and by his effectors he acts on the environment. His motor responses must be adapted to the stimuli received. Or rather, his responses must be adapted to the *objects* from which the stimuli come. When you meet a tiger walking down the street, the stimuli are merely certain

attractive colors along perhaps with sounds and odors, but you react to the tiger as an object. You react to him as an object in a certain situation, for when you see him behind bars in the zoo your reaction is different. You deal with the environment and with objects, as we have said time and again. You cannot deal effectively with the environment without in some sense knowing the environment. It is not the stimuli that you must know but the objects out there in the environment, for your behavior has to conform to those objects. But how is it possible for the organism, confined as it is within its own skin, to know anything out there and deal with it effectively? *O* must observe, yes; but how is it possible for *O* to observe anything except stimuli and their combinations—such as stripes and roars? He does go beyond the stimuli and observe objective facts: things and events with their qualities and relations.

The problem of explaining how the individual can and does observe objective facts is a fascinating but difficult one for the psychologist. A little start toward an explanation is offered by our old formula:

$$W - S - Ow - R - W$$

The environment is emitting stimuli which reach *O*'s receptors, and *O* is responding by movements which take effect in the environment. The small *w* attached to *O* symbolizes *O*'s situation-and-goal set. If we are allowed to assume that *O* at any time is adjusted to the situation as already known, his situation set is a framework ready to receive new stimuli as they arrive. In this framework they have objective meaning; they tell something further about the situation.

Our assumption furnishes a basis for explaining observation, but of course it does not carry us far. We have before us the same general questions as in the study of learning, the questions, What? and How? What is observed and how is it observed? Any light we can get on these questions should help us to answer the practical question, how the powers of observation can be developed and improved.

It is a large field for study, since all the senses are used in observation, each sense according to its own peculiarities. We devote three chapters to the subject, this one on observation in general and the following chapters on the use of the several senses.

WHAT IS OBSERVED?

Without attempting to keep our *what* and *how* questions entirely separate, we will begin by a brief survey of the variety of facts that are observed.

Observing objects and observing stimuli. In the main it is true as has been assumed that objects rather than stimuli are observed. But the stimuli are there and can be observed if the individual trains himself to hold his attention on the stimuli themselves and not to follow his natural tendency to get their objective meanings. With your eyes closed, lift a chair and report what you observe. You probably report that the chair is fairly heavy, an objective fact. But now ask yourself what actual stimuli you get from the chair, and you notice pressure on the skin of the hand that lifts the chair, a pull at the elbow increasing until the chair comes up, etc. You utilize these stimuli in observing the objective fact of weight and ordinarily you are scarcely aware of the stimuli but only of the objective fact. Similar examples will be given in considering the senses of sight and hearing.

Signs and meanings. The stimuli that we get from the environment are signs; the objective facts that we observe are the meanings of those signs. So intent are we to get at the objective facts that we ordinarily are scarcely aware of the signs. We pass as quickly as possible to the meaning.

(The connection between sign and meaning must usually be learned by experience. Observation is therefore dependent on previous learning. There is a two-way relation between learning and observation; for while we learn by observation, we observe by use of what has previously been learned.)

We have before our eyes merely a *sign* of some fact, but we perceive the fact which is the *meaning* of the sign.

We look out of the window and "see it is wet today," though wetness is something to be felt rather than seen. What we have before our eyes is some sign of wetness. Sign and meaning are connected by learning, and meaning may be called a conditioned response to the sign. For Pavlov's dogs the bell followed regularly by food became a sign of food. In the same way, the child sees a bit of ground that looks peculiar, steps there and is gratified to find a puddle; so the visual appearance becomes a sign of wetness.

Any stimulus characteristic of a given object may serve as a sufficient sign enabling us to perceive the object. To perceive the presence of an airplane overhead we need only a low droning sound. The sign may be very sketchy in comparison with the object. The outline drawings of persons, animals, houses, trees, that are common in children's picture books, and that the child understands at an early age, are certainly much reduced from the visual appearance of the real objects. A person or thing seen in the distance presents a much smaller and less detailed picture than when close at hand, but still can be recognized.

Social perception. By the senses we perceive the motives and intentions of other people, their sincerity, intelligence and many other traits. We see them angry, bored, amused, full of energy. To be sure, none of these human characteristics is directly and fully sensed, but that is the case also with many characteristics of inanimate objects which we perceive by aid of the senses. We perceive anger or sincerity in much the same way that we perceive moisture by the eye. A good share of the child's undirected education consists in learning to perceive the intentions and characteristics of other people by aid of little signs. He learns to read the signs of the weather in the family circle, and he learns in some measure to be a judge of men.

It would be very valuable if psychology could succeed in analyzing out the signs by which such a trait as intelligence or "will power" is perceived, so as to reduce such observation to a science. Some persons who themselves are keen observers of such traits have put forward systems, based upon

the shape of the face, etc. They think they perceive human traits according to their systems, but the systems fail in other hands, and are undoubtedly fallacious. No good judge of character really relies on the shape of the face; he relies on little behavior signs which he has not analyzed, and therefore cannot explain to another person.

You can tell very little regarding a person's intelligence from his photograph. Photographs of persons of various degrees of intelligence are placed before those who are reputed to be good judges, and their estimates compared with the test ratings, and there is no close correspondence. You might almost as well look at the back of the photograph as at the front.

Esthetic perception. Beauty and humor can be observed through the senses, though we might debate for a long time over the question whether they are facts in the environment. Is a landscape beautiful when no one is there to see it, and is a situation funny if no one is actually amused? At any rate, such esthetic values are observed, though there are great individual differences. Some people are blind to beauty and humor that other people clearly perceive. Many a one fails to see the point of a joke, or the humor of a situation, which is clearly perceived by another. Many a one sees only a sign of rain in a great bank of clouds, only a weary climb in the looming mountain.

> A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more.

It would not be quite fair to describe such a one as lacking in feeling; he probably has on occasion the same feelings as another man, but he is lacking in perception of certain values. He probably tends to practical rather than esthetic perception. To see any beauty in a new style of painting, or to sense the humor in a new form of humorous writing, you need to be initiated. A complex situation presents an almost unlimited range of facts that might be observed; no one perceives them all, and which ones he shall perceive depends on

his nature and training, as well as on his attitude at the moment when the situation is presented.

Many other facts that are observed, such as number, quantity, space and time, will come out from our consideration, continued through this and the following chapters, of the difficult question, *how* we observe.

SELECTIVITY AND COMBINATION AS LAWS OF OBSERVATION

In looking for general characteristics of the organism's activity (p. 38) we came across the principles of selectivity and combination. The organism is highly *selective* with regard to stimuli and also with regard to responses. Out of the multiplicity of stimuli playing on the receptors at any time, attention is paid to only a few; and out of the numerous movements in the individual's repertory, only one or a small selection is made at any one time. But selectivity is not the whole story, for the organism is apt to make a unitary response to a *combination* of stimuli, and the motor response, while a unit, combines the action of several muscles.

These principles were illustrated by facts from the psychology of attention (p. 44). We attend at any one time not to everything in sight, nor usually to the minutest possible object, but rather to an object of some size which sends us a combination of stimuli.

The same general principles hold good of perception. In perceiving an object we are ordinarily responding to a combination of stimuli, but this combination is at the same time a selection from the whole mass of stimuli acting on our receptors. Perception is both a combining and a selective response.

We perceive a face—that means that we take the face as a unit, and make a unitary response to the multiple stimuli coming from the face. At the same time, in singling out the face for observation, we isolate it from its background and disregard numerous other stimuli that are simultaneously acting on us. If we proceed to examine the face in detail, we

may select the nose and see that as a whole. We might isolate still further and observe a freckle on the nose, taking that as a whole and noting its size, shape, color, etc. Even if we went so far as to observe a single speck of dust on the skin, in which case selectivity would about reach its limit, combination would still stay in the game, for in observing the speck we should inevitably locate it or contrast it with the color of the skin or in some way see it in relation to something else. In seeing one object as near another, or as larger or smaller than another, or as differing in any way from another, we are responding not to either object alone but to the two taken in combination.

Figure and ground. The everyday experience of seeing an object standing out from its background provides a typical instance of the selectivity of perception. Usually the background, as the name suggests, lies behind the object, farther away in space. Not always, however, for in looking through a window screen or lattice at a person beyond, the person stands out against the screen as background. Experiments with nonsense drawings show that the figure that stands out need not be a familiar object, and that the ground may lie in the same plane as the figure, objectively. These facts indicate that breaking up the visible field into figure and ground is a fundamental tendency in observation.

If you draw a square and a much smaller square inside, and simply look at what you have drawn, usually the little square stands out as an object against the background of the enclosing white space. But if you draw the inside square almost as large as the outer one, and parallel to it, then what stands out as the figure is the double square, and the white space inside appears as the background. The figure has form, the ground seems like indefinite space. The figure usually seems to stand out towards you, and the background to extend around behind the figure.

In another square frame, shade in a small portion, not necessarily regular in shape. The dark part then appears as the figure, and the enclosing light part as the ground. For comparison, shade in all of another square except for a small

portion, and then the light part appears as the figure against a dark ground.

What shall be seen as figure and what left as ground depends on many conditions. The figure is apt to be compact. It hangs together by virtue of its compactness. But it may

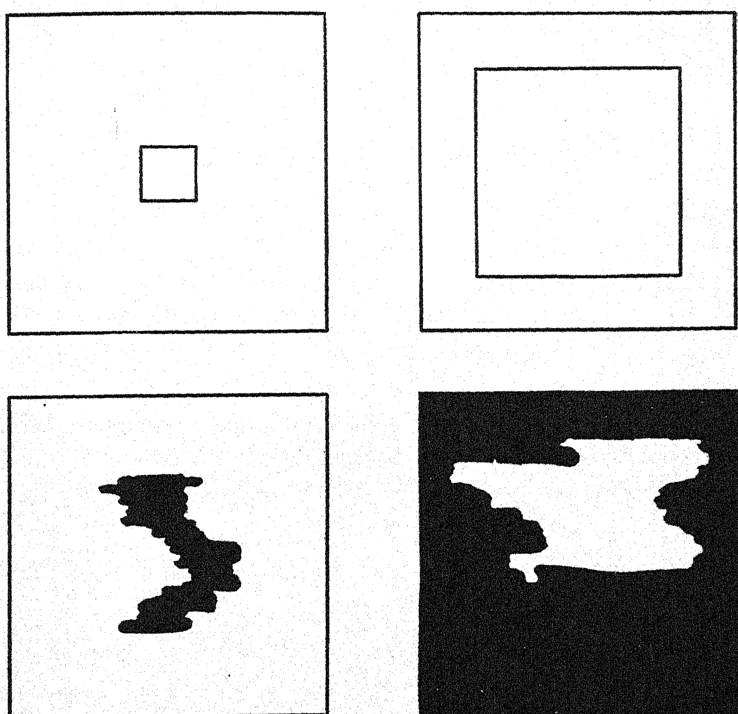

Fig. 72.—Studies in figure and ground.

be comparatively large, provided it has a definite shape that holds the parts together.

The objects in the background do not necessarily lose all their figure. More than one figure may be seen at the same time, some standing out more clearly than others. So the distinction between figure and ground is not the same as that between the field of attention and the rest of the field of consciousness (p. 45). You can attend to the ground in any of the drawings used in this experiment, but you are certainly much more apt to attend to the figure.

Figure and ground are nicely illustrated by the tune and accompaniment in music. The tune (air or melody) stands out as figure from the tonal ground of the accompanying chords. Often the accompaniment is tuneful or at least rhythmical and provides a subordinate repeated figure that is heard underneath the main tune and enhances the total musical effect. In pictorial art, too, the background serves as a foil to the main figure. In general, while interest centers in the figure, the ground plays its part in the total impression. Figure-ground perception thus combines while it selects.

Shifting perception. Keep the environment perfectly constant for more than a few seconds and you get, not an unchanging response from the organism, but a shifting from one response to another. The only alternative is for the organism to go to sleep. This law of shifting—of changing response to unchanging stimulation—we accepted as a fundamental characteristic of organismic activity (pp. 38, 48). In terms of our simplified formula,

$$S - O - R,$$

since R changes in spite of unchanging S, some change must take place in O. One such change is fatigue; the first response becomes slightly fatigued and a fresh response gains the advantage.

The tendency is to explore any new field. The behavior of the eyes, looking from one part to another of the visible field rather than remaining fixed on a single object, affords a clear example of shifting response. Attention is mobile, even when it is "sustained" in the sense that it does not wander from the matter in hand. The process of observing includes this shifting of attention, but what we mean by shifting *perception* is something different. The same object, looked at steadily, may be perceived in two or more different ways. The presented object remains the same, and attention does not wander from it, and still its appearance changes from moment to moment.

The objects used for demonstrating the shifting of perception often consist of outline drawings or skeleton models. A good object for the purpose is an assemblage of dots, arranged either regularly or irregularly. One simply looks steadily at the collection and notices whatever shifting may

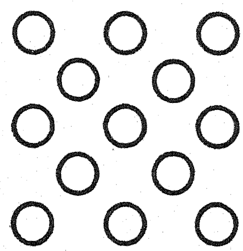

FIG. 73.—(Sanford, *5*.) A dot figure. If looked at steadily it may appear in several different forms and groupings.

occur in the grouping of the dots. One is sure to see striking changes. First the dots fall into one pattern, and then, without warning, they shift into a different pattern. The patterns are mutually exclusive; when one comes, the other

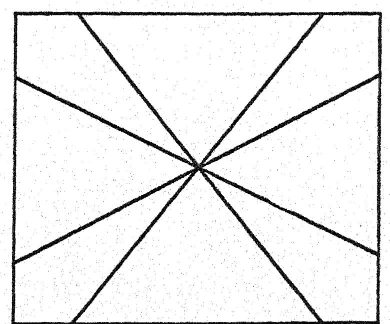

FIG. 74.—(Köhler, *2*.) A drawing that can easily be seen in at least two different ways.

goes. Objectively the dots do not change, and therefore the shifting occurs wholly in the observer. As his eyes move from point to point, the stimuli received from the dots shift their positions slightly on his retina, but much more important is the fact that he possesses two or more *grouping re-*

sponses which can easily be aroused by the same collection of stimuli. He shifts from one to another of these alternative responses.

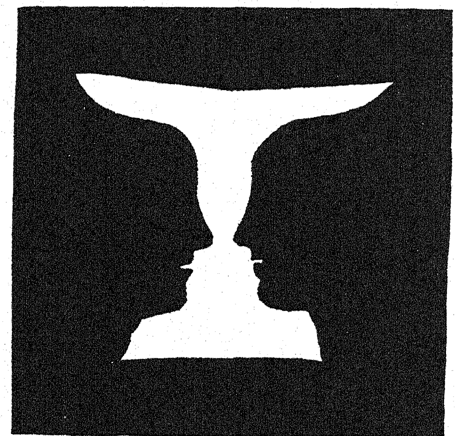

Fig. 75.—(Rubin, *4*.) Figure-ground reversal.

Figures that give shifting perception can be made of lines as well as of dots. Some shifts amount to an interchange of figure and ground. These figures are so drawn as to admit of two or more interpretations with little advantage to one

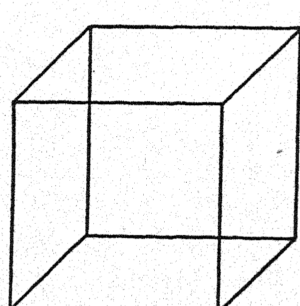

Fig. 76.—The reversible cube.

above the others. The observer can readily see such a drawing in different ways, but not in more than one way at the same time. With continued looking he gets the different appearances in succession, shifting from one response to another as in the case of the dot figure.

Shifting is especially striking when a drawing is made in ambiguous perspective, so as to represent a solid body equally well in two different positions. The transparent cube, showing near and far edges alike, is a good example. Examined steadily, the cube seems to change from time to time; it is

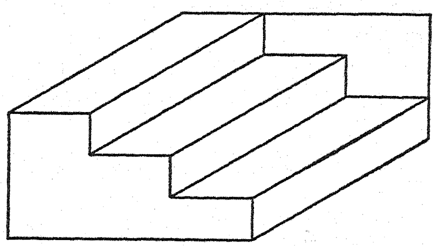

FIG. 77.—The reversible stairs.

seen, successively, in two different ways. Numerous such figures can be drawn, the most celebrated being the ambiguous staircase. Look steadily at this, and suddenly you see the under side of a flight of stairs, instead of the upper, and if you keep on looking, it keeps on shifting between these two appearances. Certain fixation points for the eye

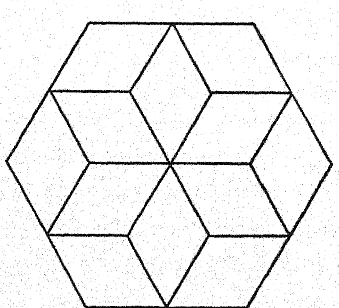

FIG. 78.—A figure which, when looked at for a long time, may appear in at least eight different ways, some of them in two and some in three dimensions.

favor one appearance or the other, and yet the appearance does not depend wholly or mainly on eye movements and changes of fixation (*6*).

Another striking case of shifting will be noticed under the name of "binocular rivalry" in the next chapter.

The main conclusion to draw from these facts is that *perception is an active response.* We often speak of "receiving an impression," as if the observer were like a camera that passively takes what comes to it. When the observer gets first one impression and then another from the same collection of stimuli, he cannot be purely passive and receptive. He must be making an active contribution. Just as he has different motor responses available, he has a repertory of perceptual responses and can see the same object in different ways.

When looking at a familiar kind of scene or object you perceive it instantaneously and seem to yourself to be simply receiving impressions. You have seen similar objects under similar conditions almost every minute of your waking life since babyhood, and your customary perceptual responses have been extremely well practiced. No wonder they seem like passive impressions. But when the object is unfamiliar or not clearly presented, the observer may be baffled and confused for a moment and may go through a series of *trial and error perceptions* before being satisfied. In night driving what seems at first to be a piece of road may soon reveal itself as the roof of a house. Trial and error perception of noises and touch stimuli can often be observed by one who is on the watch for such effects. In one instance a noise was first heard as distant thunder and then, correctly, as somebody walking on the floor above. On touching an object in the dark you may perceive it as several different things before reaching a perception that fits the situation and satisfies you.

Grouping and patterning. The visual field, including all that is presented to the eyes at one moment, contains a vast number of points and patches of differing color and brightness which could conceivably be seen as combined in many ways into various shapes. Actually, however, some groups are formed easily and others only with great difficulty. Similarly the auditory field in listening to an orchestra or to a buzz of conversation contains many sounds and sound sequences that could be grouped in various ways, but some

groupings are easy and others hard to make. The next question is whether any factors can be discovered that make it easy to group visual or auditory stimuli in certain ways. We are looking, as we did in the study of attention, for "factors of advantage." Collections of dots, such as are shown in Figs. 79-82, are used to bring out certain factors of advantage in grouping.

1. Proximity. Dots that lie close together in space are easily seen as a group, dots that lie far apart not so easily. Three drum beats close together in time fall inevitably into a group; three coming at long intervals are heard as separate beats.

2. Similarity. Dots or other small patches that are just alike are easily grouped. A collection of dots naturally breaks up into two groups when the dots are of two shapes (or colors; see Frontispiece). The similar dots are easily seen as one group, and two interlacing groups appear. Many examples could be found in the auditory field. A series of high notes hangs together, or a series of low notes, or a series of notes played by the same instrument. A series of words spoken by the same person hangs together in a buzz of conversation, because they all have the quality of this person's voice.

3. Continuity. Dots that lie in a straight line or along some continuous curve are easily grouped, or the continuity may be lugged in by faint lines joining certain dots. In sound, a sequence of notes running up or down the scale makes an easily heard pattern.

4. Inclusiveness. A group or pattern that includes all the elements has an advantage over groupings that leave some elements out of account. If all the elements fall readily into a single group, that pattern has the advantage; if they do not, the pattern consists of two or more groups, or of a group with stragglers left outside (2, 7).

5. Familiarity of a pattern or object gives it the advantage over others that are less familiar. Picking out a circle or a human profile from a mass of lines is made easier by the familiarity of these figures.

6. The *set* or *readiness* of any moment is a factor in determining what shall be perceived at that moment. If you are set to see a certain pattern or object, or to hear a certain rhythm, that pattern has the advantage over others equally familiar or compact.

Puzzle pictures prove that familiarity and readiness are not

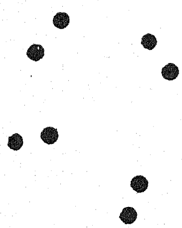

FIG. 79.

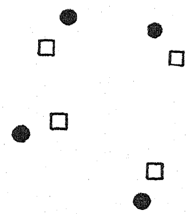

FIG. 80.

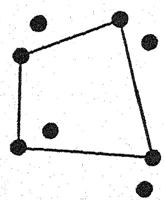

FIG. 81.

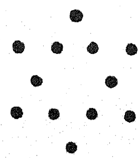

FIG. 82.

FIG. 79.—Proximity favors grouping.
FIG. 80.—Similarity favors grouping.
FIG. 81.—Continuity favors grouping and combining.
FIG. 82.—The most inclusive grouping has an advantage. This collection of dots contains two hexagons and two interlacing triangles, all perfectly good figures which show themselves from time to time but which are at a disadvantage in competition with the all-including star.

the *only* factors operating, since often you simply cannot find the hidden face, though you are set for faces, and though faces are certainly familiar enough. What conceals the face is the advantage possessed by the other figures that you do see, an advantage due partly to the primary factors already mentioned, and partly to yet another factor, perhaps as important as any. The whole picture in which the face is hidden is a coherent whole, while the hidden face is but an isolated fragment. You have to lose sight of the coherent whole in order to see the face. So we have our final factor of advantage:

7. The *whole that is perceived* gives the advantage to parts

coherent with that whole. This factor is perhaps the same as the continuity mentioned above, only that here we stress the whole pattern or situation as determining how the parts shall be perceived. In perception, at least, there is much truth in the saying that the whole determines the parts.

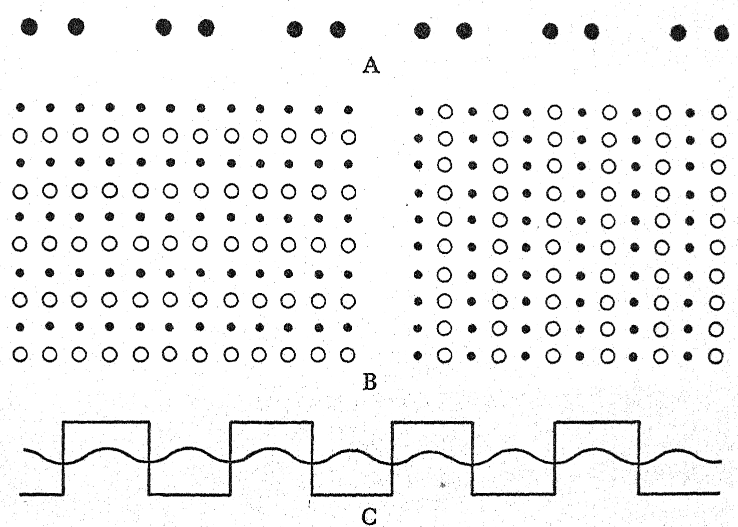

FIG. 83.—(Wertheimer, 7.) Figures showing the influence of proximity, similarity and continuity. The question is what grouping or combination is easiest. In A it is certainly easier to see pairs composed of dots that are close together than to see the pairs composed of adjacent dots lying further apart. In B you can with some effort see columns or rows composed of dissimilar elements, but lines of similars are more easily seen. In C it would require great effort to neglect the continuities and actually *see* a design composed of several parts of the wavy line combined with parts of the angular line.

Better, the whole determines the parts in certain respects, by conferring on the parts their respective roles in the whole. Fig. 82, for example, is easily seen as a star. The star confers on six of the dots the role of exterior points, and on the other six the role of interior points. The size and color of the single dots are of course properties not dependent on the whole but remaining the same even when another grouping is seen.

A tune or melody is another good example of a whole that

has properties not derived from its parts. The tune can be sung in a certain key and then transposed to a higher key and still sound the same, only somewhat more brilliant. It remains to the hearer the same tune, though every note is changed. The tune-quality depends not on the separate notes but on their interrelations. And the tune as a whole confers on each note a certain role which an isolated note does not possess (as it does possess pitch and smoothness).

The form of an object can obviously be distinguished from its material; and form qualities can be distinguished from material qualities. The difference can be brought out by thinking of garments. "The same coat," as a dressmaker might say, can be made of various materials, and different coats can be made of the same material. In speaking of a "silk coat" we are referring to a material quality; in speaking of a "long coat," to a form quality. The shoulder of a coat has a form dependent on its role in the whole coat, while the material quality of the shoulder does not depend on the whole of which it is a part but only on the material of which it is made. When a collection of red dots is seen as a triangle, the red is a material quality of the single dots and of the whole figure. The triangularity is a form quality, not dependent on the color of the dots, and the three corner dots have a role dependent on their position in the whole triangle.

The span of apprehension. Somewhat akin to the memory span that we heard of before, the span of apprehension is the answer to the question, how large a number we can perceive. Measurement of this span is one of the oldest experiments in psychology, made at first with very rough apparatus. Someone places a few marbles in a box, you take a single peek and tell, if you can, how many are there, not guessing but knowing. The span measures about four or five, if no errors are allowed.

In the laboratory we have exposure apparatus that displays a card for a fifth of a second or less, just time enough for a single view and not enough to look the card over. The experimenter prepares many cards, each containing a number

of dots, scattered irregularly over the card, and exposes the cards one at a time. The subject attempts to see all the dots, and tell how many there are. If there are only two, three or four on a card, he probably reports the number correctly every time; with five, an occasional error can be expected, and the errors increase gradually till at about twelve dots the subject can only make an estimate. Thus the span is a variable quantity even with the same individual, and it varies from individual to individual.

But how, it may be asked, can the subject in this experiment observe as many as eight or ten dots, with no time allowed for counting? Mostly by *grouping*. If there are only three or four dots, they form a single group; if there are seven, they probably appear as a group of four and a group of three. Unless the dots do fall instantly into groups, the subject cannot usually tell the number.

If the material exposed, instead of being mere dots, consists of a line of letters, three or four can be clearly read at a glance. If the letters make up familiar words, two or three words can be read at a glance. And if the words make up a familiar phrase, the whole phrase, containing as many as twenty letters, can often be read at a single glance.

The limited span of perception is another instance of selectivity. The eye furnishes more data than the brain can use. It is not because the area of clear vision is limited that the span of apprehension is so small; for the experimenter can easily arrange to present twenty dots within the area of clear vision, but the subject cannot organize so many in a moment. Perception evidently means work, and thus is forced to be selective.

If the limited span shows the law of selection, grouping shows the law of combination. Little items like dots or letters do not arouse each its own separate response, but several of them, together, arouse a single, comprehensive response (*3*).

ACCURACY OF PERCEPTION

In the experiment just described, it is not surprising that the subject could perceive instantly the number of dots in a small collection. These small numbers are so familiar that we would expect them to be recognized on sight. It is a little more surprising that one can estimate the approximate number in a much larger collection, or that one can roughly estimate the weight of a book, or the length of a room, or the speed of an automobile. Experience is of course necessary and individuals differ greatly in the accuracy of their estimates. By experience with lengths one builds up a rough scale of length which is retained in memory and used as occasion demands. By checking and correcting the estimates this memory scale or "subjective scale" can be made fairly accurate. To measure the accuracy of an individual's subjective scale of short lengths, we could proceed as follows. Ask him to mark off on a straight line a length of one foot; measure the length marked off and determine whether it is too long or too short, and the amount of the error. To do the job right we should have him make several trials, say ten, and make a distribution of his estimates, which might range from 9 to 12 inches with an average of 10.5 inches. (Instead of the range, we could compute the SD as a measure of his variability of estimate, p. 88.) We can now report to our subject that his subjective scale for a foot is too short and shows a certain amount of variation. It shows, in the psychologist's lingo, a *constant error* (or bias) and a *variable error*, and we can give him a measure of each of these errors. The constant error he can correct but the variability of performance can never be wholly eradicated, for it is inherent in every kind of behavior. Practice will however diminish the variability of a performance. Constant errors are sometimes quite large, and they themselves vary with the conditions. One minute, when you are impatiently waiting for it to end (as in taking your temperature), seems an incredibly long time. But when you are working against time, a minute seems short. The professor

is shocked when the closing bell rings, and thinks that certainly the hour cannot be up; but some of the students have been consulting their watches for quite a long while. In a court of law, when a witness is required to testify regarding the length of time occupied by a certain event, he is likely to give a very erroneous estimate. Whether he will overestimate or underestimate the time depends on his attitude and desire when he witnessed the event in question. Under certain conditions an actual time of one minute would surely be reported as five minutes or more.

Weber's law. Let us continue the experiment on estimates of length by asking our subject to mark off a distance of one inch a number of times. He certainly will not make as large errors as in marking off a foot. Try him with a quarter-inch and his errors will be still smaller; try him with a yard and they will certainly be larger than in estimating one foot. Try him with 100 feet and it will be strange if his errors do not run up to several feet.

Let us turn the problem around and ask him to estimate the length of a seen line. Try him with a line 1.5 inches long and he probably will not err more than a fraction of an inch. Try him with a line 10 feet long and he may be a foot off. Try him with a line 100 feet long and he will not estimate it to the nearest foot, let alone the nearest inch, since he knows it would be absurd to attempt any such precision.

If the error of estimate were exactly proportional to the objective length judged, the result would conform to Weber's law. (The variable error is used in testing this law.) If the error in estimating a foot is one inch, it should be 1 foot in estimating 12 feet, and 10 feet in estimating 120 feet, to conform exactly to Weber's law. This famous law applies to all kinds of perceived quantities: visible length, weight, brightness of light, intensity of sound. A general statement of the law is as follows: In any given kind of perception, *equal relative (not absolute) differences are equally perceptible*. The law is approximately but not precisely correct.

According to the law, the difference between two weights of 10 and 11 ounces should be just as easy to perceive as the difference between 10 and 11 pounds. The difference is 1 part in 10 in both cases. In illumination, the difference between 20 and 21 candlepower should be just as perceptible as the difference between 400 and 420 candlepower, the difference being 1/20 in each case. A difference of 1 part in 10 is much more easily perceived in illumination than in weight;

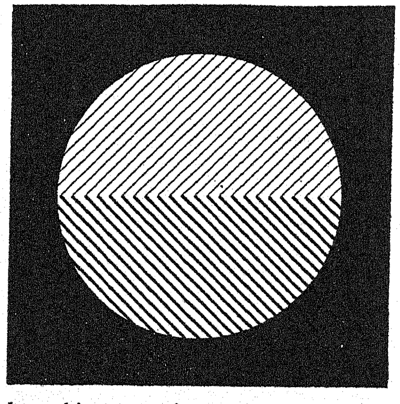

FIG. 84.—What the subject sees in an experiment on discrimination of brightness: two semicircles of different brightness.

but that fact is not contrary to the law, which states, for each separate kind of magnitude only, that the stimuli must be in a constant ratio in order to make the difference equally perceptible.

Different *kinds* of magnitude are, as a matter of fact, perceived with quite unequal accuracy. Perception of brightness is probably the most accurate, as under favorable conditions a difference of 1 part in 100 can here be perceived with very few errors. Visual perception of length of line is good for about 1 part in 50, perception of lifted weights for about 1 part in 10, and perception of intensity of sound for about 1 part in 4.

As an example of the data used to check Weber's law, we cite an experiment in discrimination of brightness. The subject sees before him a disk of white light; its upper and lower halves are illuminated from two separate sources; the bright-

ness of the lower half is kept constant while the brightness of the upper half is varied by the experimenter and compared by the subject with the lower half. The experimenter starts with both halves the same and increases the brightness of the upper half, step by step, till the subject perceives the difference. The experimenter then starts with the upper half much brighter and diminishes its brightness, step by step, till the subject no longer perceives any difference. The test is repeated till the average difference is determined that the subject can barely perceive. Suppose this difference to be 2 physical units when the lower half of the disk has a brightness of 100 units; then the just perceptible difference is .02 of the basic brightness. The experiment is extended to other values of the basic brightness to see whether this fraction is the same for all values, as it should be according to Weber's law. The results obtained from one subject are given in an adjoining table.

Basic Brightness in Millilamberts	*Just Perceptible Difference as a Fraction of the Basic Brightness*
.01	.35
.1	.13
1	.05
10	.03
100	.02
1,000	.02
10,000	.02
100,000	.03

One millilambert is the brightness of matt white paper lying on a table and illuminated by a 10 candlepower lamp (without reflector) one meter above the table. This is quite moderate brightness. (Reference to this classical experiment can be found in *1*.)

Is Weber's law verified or not? Confining our attention to the range of moderate and high intensities, we find the fraction nearly constant, but in the range of low intensities it is much larger. Weber's law, then, is approximately a true statement for moderate and high intensities of light, but

breaks down at low intensities (perhaps because the rods, instead of the cones, do most of the work at low intensities, p. 476).

The smaller the fraction, the greater the ability to distinguish *objects* on the basis of brightness. Take two pieces of gray cloth, one slightly darker than the other, and lay them side by side. You want to know which is darker. According to the table, you couldn't tell so well under dim as under moderate to high illumination. The difference between the two grays is a fraction that remains physically constant, no matter how strong or weak the illumination. Since the eyes are used mostly in viewing objects by reflected light, Weber's law, so far as it holds good, means that the eyes function equally well over a wide range of medium and high illumination.

In the other senses, Weber's law has about the same degree of validity. It always breaks down at low intensities, and stands up fairly well over the range of moderate and high intensities. The basis of the law is probably physiological (*1*).

ILLUSIONS

When any process goes wrong it is apt to reveal its inner workings more clearly than when it runs smoothly. We may hope, then, to learn something of the process of perception from the study of illusions.

An illusion is a false perception. Any error of observation might accordingly be included under the head of illusions, but the term is usually reserved for errors that are large and surprising. An illusion consists in responding to a sensory stimulus by perceiving something that is not really there. Something is there and has delivered a stimulus, but the stimulus is misread. Instead of the true object a false object is perceived. The false object must have some advantage over the true object, and illusions can be classified according to the factor of advantage that enters and causes the false perception. Aside from a few illusions which seem to be due to peculiarities of the peripheral organs—such as the fact

that a vertical line looks longer than an equal horizontal line—the following classes are recognized.

1. The false object has the advantage of familiarity. A stimulus (or combination of stimuli) which is nearly identical with the stimulus commonly received from a certain object easily arouses the old familiar response of perceiving that object. One illusion of this type dates from Aristotle (B.C. 330), the first man to write books on pyschology. Cross two fingers, and touch a marble with the crossed part

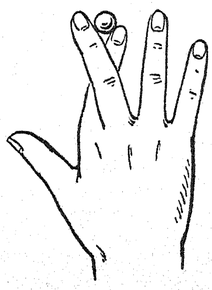

FIG. 85.—Aristotle's illusion.

of both fingers, and you seem to feel two marbles. A pencil can be used in place of the marble. In the usual position of the fingers, the stimuli thus received would be rceived from two objects, not from one.

Another good instance of this type of illusion is called the "proofreader's illusion," though the professional proofreader is less subjcet to it than anyone else. It is almost impossible to find every misspelled word and other typographical error in reading proof. Almost every book comes out with a few errors, in spite of having been scanned repeatedly by several people. A couple of misprints have purposely been left in the last few lines for the reader's benefit. If the word as printed has enough resemblance to the right word, it arouses the same response and enables the reader to get the sense and pass on satisfied.

2. The false object has the advantage of preparatory set. When an insane person hears the creaking of a rocking-chair as the voice of someone calling him bad names, it is because

he is preoccupied with suspicion. We might almost call this an hallucination (p. 355) since he is confusing his auditory images with sensations; it is, at any rate, an extreme instance of illusion. In a milder form, similar illusions are often momentarily present in a perfectly normal person, who while searching for a lost object may think he sees it whenever anything similar meets his eyes. A mother, with the baby up-

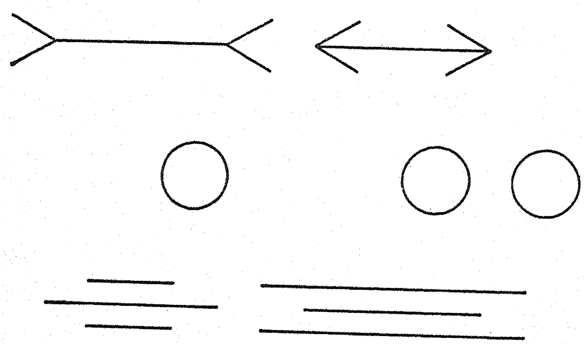

Fig. 86.—The Müller-Lyer illusion in three of its many forms. In the upper figure the two horizontal lines are to be compared in length. In the second figure the open space between the first and second circles is to be compared with the space including the second and third circles. In the third figure the lengths of the two middle lines are to be compared. All the six lengths in question are drawn to be objectively equal.

stairs very much on her mind, imagines him crying when she hears a cat yowling out of doors. The ghost-seeing and burglar-hearing illusions belong here as well. An expectant set gives the advantage to objects congruous with itself.

The *size-weight illusion* shows the effect of preparatory set in a very different way. This interesting laboratory experiment follows up the old catch, "Which is heavier, a pound of lead or a pound of feathers?" A pound's a pound, we shrewdly answer. But lift them, and the pound of lead feels much heavier. To standardize the conditions, you take two round wooden pill-boxes, one much larger than the other, and load them with paraffin and shot so that both weigh the same; then ask someone to lift them. He will have no doubt at all that the smaller box is the heavier; it may seem twice as heavy. The visual appearance of the two

boxes has aroused an adjustment to their apparent weights, with the result that the larger box is lifted strongly and comes up easily, while the little box is lifted weakly, comes up slowly and feels heavy. In this case perception swings to the opposite of what is expected, because the stimulus received simply will not fit in with the expectation, while in the other cases cited the stimulus can be made to fit and is perceived in accord with the expectation.

3. The false object has the advantage of total impression. The true object or fact can often be perceived only by

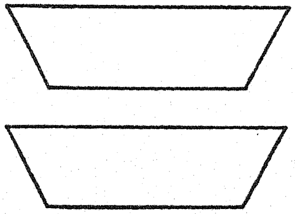

FIG. 87.—The pan illusion. Which pan is the larger? The whole layout suggests one pan ready to go inside the other and makes it difficult to isolate the parts to be compared.

analysis and attention to detail—a laborious process which we tend to avoid. Under this head belong a whole army of illusions produced by odd combinations of lines. A figure is so drawn as to hamper the observer in isolating the fact he is supposed to perceive. The best example is the Müller-Lyer figure: two equal lines or distances are embellished with extra lines which lead the observer astray. While intending to compare the two specified lines he is more likely to take the whole figure in the rough and to compare the distances between its main masses. He does not succeed, unless after practice, in isolating the precise object he intends to observe.

The pan illusion clearly results from this difficulty of isolating a precise fact from a global impression. Two other famous illusions which are shown here are not quite so readily understood but probably belong under this general head.

Though these illusions seem mere curiosities, and far from everyday experience, they enter in some degree into every

figure that is not perfectly square and simple. Any oblique line or complication of any sort is sure to alter the apparent

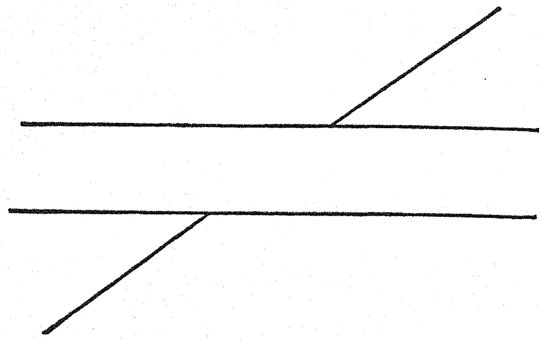

FIG. 88.—The Poggendorf illusion. Are the two oblique lines part of the same straight line?

proportions and directions of the figure. A broad effect, a long effect, a skewed effect, may easily be produced by lines introduced into a dress, into the front of a building, or into

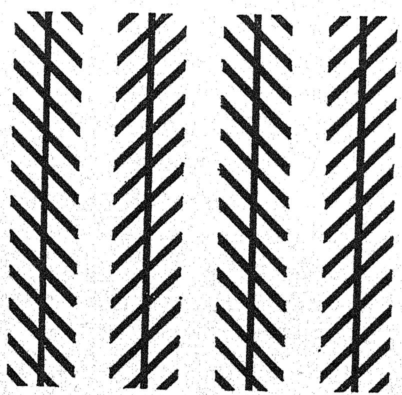

FIG. 89.—The Zoellner illusion. The long lines are really parallel. The illusion is increased by holding the page in an oblique position. It is more difficult to "deceive the eye" regarding horizontal and vertical lines than regarding oblique lines.

If you hold the page flat and sight along the oblique lines you get a three-dimensional appearance.

a design of any sort; so that the designer needs to have a practical knowledge of this type of illusion. The esthetic

effect of a given form may be quite altered by the introduction of apparently insignificant extra lines.

MANAGEMENT AND IMPROVEMENT OF OBSERVATION

To judge from the various illusions which have just been surveyed, poor observation results (a) from being bound by old habits and closed to new impressions, or (b) from preoccupation and bias, or (c) from resting content with total impressions. The good observer is able to escape from these lines of least resistance, and to use some freedom in his outlook on the environment. And yet he has to use the same "factors of advantage" in his good observation. Without a background of past experience he would be lost in a new situation, not knowing what to look for. Without preparatory set he would be looking for nothing in particular and probably would find nothing. Without combination he could see only isolated and insignificant details. The good observer needs to have the virtues of his defects and to escape from the defects of his virtues.

Assimilation of the new to the familiar. A child on first seeing a squirrel called it a "funny kitty." The new was assimilated to the old—yet not completely since the new animal was "funny." Always, in observing anything new, we have to use the intellectual tools already at our command. Good examples are seen in the experiments on memory for figures (p. 352). In carefully observing a nonsense figure, with a view to drawing it from memory, one looks for some resemblance to an object. This useful technique contains a danger, for the figure drawn from memory usually deviates from the given figure in the direction of the object. If the observer wishes to learn anything new, he needs to do more than assimilate. He needs to notice the difference as well as the similarity.

Scientific observation. We should be able to learn something from the scientists on the essentials of good observation. The first thing we notice is their strong reliance upon

observation. They submit their theories to the test of observation and abide by the result. All of us would probably become better observers if we imitated the scientists in this respect. The second thing to notice is that the scientist approaches nature with questions to be answered by observation. Of course he has his eyes open for unexpected phenomena, and his background of knowledge enables him to seize the significance of an unexpected phenomenon, as happens from time to time when striking discoveries are made "by accident." But in most instances he observes the answer to a definite question that he has in mind. A good question is a great sharpener of observation. Where possible, the best plan is to decide beforehand exactly what needs to be observed and then to focus attention on this precise point.

The scientist goes to great trouble to make his decisive observations as easy as possible. Instead of straining his eyes to see a small specimen, he uses a microscope. He invents instruments of precision and makes them as foolproof as possible. If possible he repeats an observation and has it checked by another observer. He records his observations on the spot to avoid errors of memory.

How does the scientist escape the error of bias in making his observations? Often he has a personal interest in a theory and cannot but hope, however devoted he is to the truth, that the facts will support his theory—or, perhaps, disprove someone else's theory. But he cannot afford to let bias creep in, because so much depends on his data. He may propose to make practical application of his findings, and certainly they are to be built into the larger edifice of his science, and if they are not right something is sure to go wrong. His fellow-scientists will discover the error. Science, even pure science, is a social enterprise, and the scientific group provides the best corrective for the bias of the individual.

In all these respects, the would-be good observer can learn from the experience of the scientists.

Training of observation. Experiment shows here, as in the case of memorizing (p. 361), that practice along one specific line greatly increases skill in that particular line, but that the

transfer to other lines is likely to be small, unless the practice has been accompanied by study of the principles underlying good work. Some principles of good observation have just been mentioned. Another came out when "knowledge of results" was found to be an important source of motivation (p. 403): when one is learning any kind of observation one should get as prompt a check on each observation as conditions allow.

Summary of the chapter. Observation is much more central in behavior than at first appears, interlocked as it is with learning and motivation. The facts observed are objects rather than stimuli in most cases, and include the emotions and intentions of other people. The stimulus received is a sign and the observer perceives its meaning. In seeking to penetrate the process of perception we run into our old principles of selectivity and combination, illustrated by figure and ground and by grouping of figures. The accuracy of perception, on being measured, is found to be limited, subject to constant and variable errors and to illusions dependent on set, global impression, and assimilation to the familiar. Weber's law is found to be approximately true for medium and high intensities of the stimulus.

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Chapter XIV

The Sense of Sight: Visual Sensation and Perception

OBSERVATION, besides being considered in general as was done in the last chapter, can be investigated in much greater detail. Since we observe by use of the senses and each sense has its own peculiarities, there is an enormous amount to be learned. An enormous amount of information is available on the senses, which have been studied by physiologists as well as by psychologists. Most of this material lies outside the scope of this book, but a few especially significant points will be brought to the reader's attention.

What do we see? The common-sense answer is that we see the objects and happenings that are before our eyes. But when we ask how we can see an object out there, we learn from physics that what we actually see is light, emitted from the sun or some other luminous body and reflected from the object into our eyes. Do we see objects or do we see light? Do we see the colors of objects or the colors of light? This last question is a very practical one to the landscape painter. Suppose his subject to be a white cow lying on the green grass in the shade of a tree. He sees the cow to be white and the grass to be a light green, but if he lays on pure white for his cow and light green for his grass, he has altogether lost the shade of the tree. To reproduce the picture that he has before his eyes, he has to darken the cow and the grass, he has to paint the white cow gray and the light green grass dark green. The painter has to learn to see lights and shades and the color of the light, instead of the colors of objects.

It is a difficult task for the novice in painting to see light and the colors of light—which might be called picture colors—and to get away from the customary seeing of objects and their colors. For ordinary purposes it is more useful to see the colors of the objects themselves than to see the picture colors which those objects deliver to the eye at any moment. There is no doubt that ordinarily we go as far as we can away from seeing light and toward seeing objects.

Sensation and perception. Evidently there are two meanings of the verb "see," and it would be desirable to have two psychological terms to mark the distinction. Let us call the seeing of light by the term "visual sensation," and for seeing objects or environmental facts let us use the term "visual perception." Similarly in the case of smell, olfactory sensation is the sensing of the odor stimuli that enter the nose, while olfactory perception is the smelling of odorous substances present in the neighborhood. In general, when we speak of sensation we are thinking of stimuli and investigating the relationship of the individual's experiences and activities to the various stimuli which reach his receptors; and when we speak of perception we are thinking of objects and are investigating how well the individual's experiences and behavior correspond with the objective facts. In his practical life of relation with the environment, the individual is bent on perception; but his receptive apparatus seems built for sensation. He certainly knows the environment only by utilizing the stimuli received.

VISUAL SENSATION

Before following up any further the process of seeing objects, we need to know something of the eye and of visual sensation. The eye, of course, is only part of the visual apparatus. The eyes are connected by their sensory nerves, the optic nerves, with the interbrain, and this in turn with the occipital lobes of both cerebral hemispheres. The occipital lobes do the observing in the sense of seeing objective facts. The eyes receive the stimuli, which produce nerve currents

passing back to the interbrain and cortex, and the cortex probably does all the grouping, patterning and recognizing of objects (p. 276).

The eye. The human eye is a registering optical instrument, like the camera. In fact, it is a camera, the sensitive plate being the retina, which differs from the photographic plate in recovering after each exposure so as to be ready for

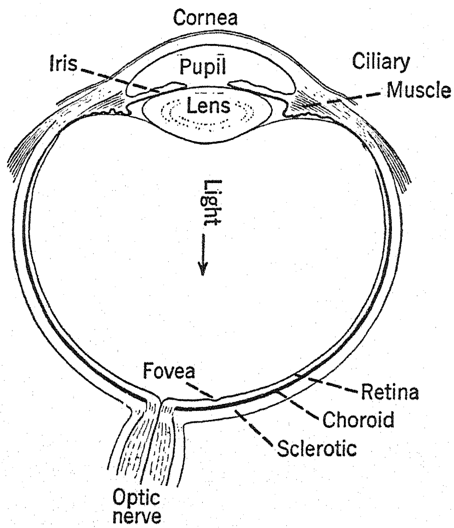

FIG. 90.—Horizontal section of the eyeball.

the next one. Comparing the eye with the familiar camera, we find that the outer tough white coat of the eyeball, the sclerotic coat, takes the place of the wood or metal of the camera box, while the black choroid coat, lining the sclerotic, corresponds to the coating of paint which blackens the inside of the camera box and prevents stray light from entering and blurring the picture. At the front of the eye, where light is admitted, the choroid gives place to the colored iris, with the hole in the center that we call the pupil of the eye. The iris has little muscle fibers in it, which regulate the size of the pupil; it corresponds to the adjustable diaphragm of the camera. The sclerotic gives place at the front of the eye to the curved, transparent cornea, which is a powerful lens.

Just behind the pupil is another lens, adjustable in curvature by the action of the little ciliary muscle. This muscle corresponds to the focusing mechanism of the camera; by it the eye is focused on near or far objects. The aqueous humor

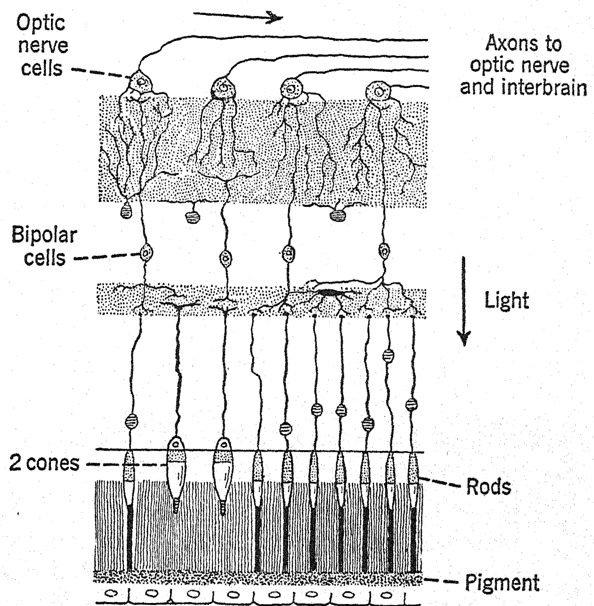

FIG. 91.—Sense cells and nerve cells of the retina. The light, reaching the retina as shown in Fig. 90, passes through the nearly transparent retina till stopped and absorbed by the pigment layer, and there produces chemical changes which stimulate the tips of the rods and cones. The rods and cones pass the impulse along to the bipolar cells and these in turn to the optic nerve cells. The axons of these latter cells extend by way of the optic nerve to the interbrain. See p. 276.

(in front of this lens) and the vitreous humor (behind the lens) fill the eyeball and keep it taut and spherical, while still, being transparent, they allow light to pass through to the retina. The retina is a thin membrane, lining the rear of the eyeball, and containing the sensitive cells.

The visual receptors. The retina contains sense cells of two forms, the rods and the cones. They are located at the back of the retina, next to the pigment layer. Probably the incoming light first produces some chemical and electrical

change in the pigment, and this change stimulates the rods and cones.

The cones are more highly developed structures than the rods. At the fovea, a little depression in the retina, straight back from the pupil, only cones are present, and this is the "center of clear vision." In looking straight at a small object so as to see it distinctly, we turn the eyes so that the light from that object falls on the fovea. Outside of this little central region, rods and cones are intermingled, with fewer and fewer cones the further out in the retina you go. The further out you go, also, the less distinctly both form and color are seen, from which fact it is inferred that form and color vision depend mostly on the cones.

Rod and cone vision; adaptation of the retina to dim and strong light. The first reaction of the eye to change of illumination is a widening or narrowing of the pupil. A slower but more effective change occurs in the retina itself, and sensitizes the retina to the degree of illumination. Go into a dark room, and at first all seems black, but by degrees, provided there is a little light filtering into the room, you begin to see, for your retina is becoming dark-adapted. Come out of the dark into a bright place, and at first you are "blinded," but you quickly get used to the bright light and see distinctly, your retina having become light-adapted.

Complete dark adaptation requires a stay in the dark of half an hour, and leaves the eye a full million times as sensitive to faint light as on first entering the dark from bright sunlight.

While in the dark, after becoming dark-adapted, you will notice that you see only light and shade and no colors. Another significant fact is that the fovea, which has only cones and no rods, has the best color vision, but does not become well dark-adapted and is almost blind in very dim light. These facts are taken to mean that vision in dim light, or *twilight vision* as it is sometimes called, is rod vision and not cone vision. The rods become sensitized to very faint light, far outstripping the cones in this respect. On the other hand, not the rods, but only the cones, have color vision.

Individuals differ considerably in their power of dark adaptation, largely because of differences in their diet. Lack of vitamin *A* in the diet prevents the formation of the retinal pigments, especially of the "visual purple" which plays a part in dark adaptation. Individuals whose diet is deficient in vitamin *A* show some degree of night blindness, due to imperfect dark adaptation. In some samples of apparently normal persons, 30-50 percent have been found to have some night blindness. In an experiment to test the importance of vitamin *A*, "all dairy products, colored vegetables, liver, kidney and other selected foods" were excluded from the diet of a healthy young man for a period of 34 days (all other requirements except vitamin *A* being supplied by suitable capsules, etc.). His power of dark adaptation declined gradually till the sensitivity of the cones was reduced to ⅓ of normal, and that of the rods to ⅑ of normal. At the end of the period ample amounts of vitamin *A* were administered and the subject's dark adaptation promptly returned to normal (*16*).

Stimulus and sensation in the sense of sight. Without going into the physics of light to any extent, we can say that light has so much of the vibratory character as to allow us to speak of its *wave length*. In the rainbow, or spectrum, light of the different wave lengths is separated and spread out in order before us. At the red end of the spectrum, the wave length of the light is 760 millionths of a millimeter, and at the violet end it is 390 millionths. In between are waves of every intermediate length, appearing to the eye as orange, yellow, green and blue, with all their transitional hues. A wave length of 580 gives yellow, one of 520 gives green, one of 480 gives blue, etc. Outside the limits of the visible spectrum, there are longer and shorter waves, incapable of arousing any sensations of light, though the long waves, beyond the red, excite the warmth sense of the skin, and the very short waves, beyond the violet, while arousing none of the senses, do tan the skin and produce other physiological effects.

Seldom does the light reaching the eye from any point

consist of waves that are all of the same wave length. Sunlight contains waves from all parts of the spectrum and appears as white. The light from an electric bulb appears pale yellow because while containing waves from all parts of the spectrum it is relatively strong in the middle wave lengths. Light that has passed through a sheet of good red glass comes out pure red because all but the red waves are strained out by the pigment in the glass. Thus light varies in amount of *mixture* of different wave lengths. Light varies also in *intensity* or energy.

The stimulus entering the eye from any point can vary, then, in three ways: in wave length, in energy, and in amount of mixture; and we now ask what difference in sensation corresponds to each of these differences in the stimulus.

To the energy or intensity of the stimulus corresponds the brightness or *brilliance* of the visual sensation. In modern scientific usage, "brightness" refers to the stimulus, "brilliance" to the sensation. If you gaze steadily at a white surface exposed to constant illumination, its physical brightness remains the same, while its apparent brightness, or brilliance, decreases because the eyes are becoming light-adapted. The brilliance dimension of visual sensation extends from dark to light—from absolute darkness to an undefined maximum.

To the wave length of the stimulus corresponds the *hue* of the visual sensation. The hue series extends from red through yellow and the other colors of the spectrum to violet and then by way of the purples back to red again. It is a circular series.

To the mixture of wave lengths in the stimulus corresponds the *saturation* of the color sensation; the more mixture the less saturation. A full, pure color is saturated, a pale or a dull color is unsaturated. A saturated color need not be very bright, and a bright color need not be saturated at all. Pink and reddish brown are both unsaturated red; pale blue and bluish gray are alike in being unsaturated blue. (Some colors are shown in the Frontispiece.)

These are the general correspondences between the physical light and the visual sensation, but the whole relationship

is much more complex. Brilliance depends, not only on the energy of the stimulus, but also on its wave length. The retina is most sensitive to waves of medium length, corresponding to the yellow of the spectrum. A given amount of physical energy arouses a much stronger light sensation if

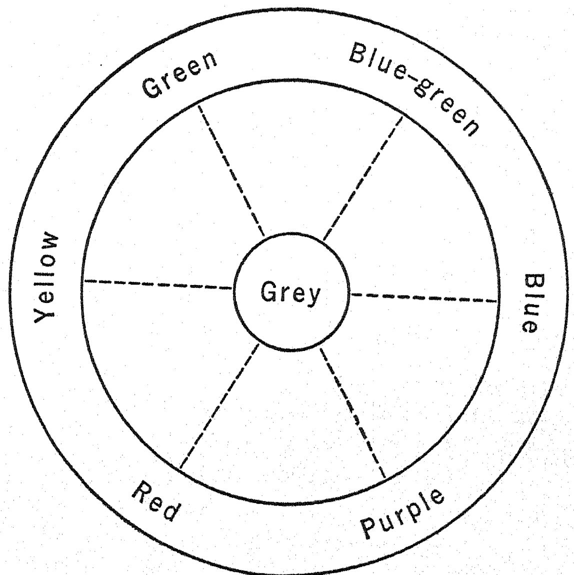

FIG. 92.—The color circle. Complementary colors (see later) are placed diametrically opposite each other.

its wave length is medium than if it belongs near the red or the blue end of the spectrum.

Color mixing. Hue, as has been said, depends on the wave length of the light stimulus, each hue being a response to one particular wave length. But this is not the whole truth. Any hue can be got without its particular wave length being present at all, by mixing wave lengths lying on both sides of this particular one. For example, the orange color given by wave length 650 is given also by mixing wave lengths 700 and 600; a mixture of red and yellow lights gives orange.

A point of experimental technique: in mixing colored lights for the purpose of studying the resulting sensations,

we do not depend on mixing paints, but we throw both lights together into the eye or on a white screen. We can also, by virtue of a certain lag or hang-over in the responses of the retina, mix lights by use of the "color wheel," which throws them in rapid alternation into the eye.

By mixing black and white in different proportions we obtain the whole series of dead grays. By mixing white or gray with any saturated color we make it less saturated. By mixing black with any color we lower the brilliance of that color.

By mixing red and yellow, in different proportions, we get all the hues intervening between red and yellow—all the oranges. By mixing yellow and green we get all the yellowish greens, and by mixing green and blue, all the greenish blues. Finally, by mixing blue and red, we get violet and the purples. Purple has no place in the spectrum, since it is a sensation which cannot be aroused by the action of any single wave length, but only by the mixture of long and short waves.

Now what happens if you add yellow to blue? Those who know about mixing paints will say that you will get green; but mixture of paints is decidedly not adding lights, for each paint *absorbs* or subtracts part of the light, and the effect of the double subtraction is very different from *adding* blue and yellow. If you add blue and yellow, you get white or gray. Two wave lengths which, when acting together on the retina, give a white or gray sensation, are called *complementary*. Yellow and blue, then, are complementary.

Red and green are sometimes said to be complementary, but such a statement is inaccurate, for if you take typical red and green, such as brick-red and grass-green, and mix them, you get a dull yellow, but never a white or dead gray. The complementary of red is bluish green, and that of green is purple.

Red and green, however, like blue and yellow, may be called a *disappearing color pair*. When you mix blue and yellow, both disappear, and you get the sensation of white, in which there is no resemblance to either yellow or blue.

When you mix red and green, too, both disappear, and the sensation of yellow emerges.

Elementary, primary and salient hues. There are thousands and thousands of distinguishable colors, including all the shades and tints, and every one is simple or elementary in this respect, that you cannot actually *see* any other colors in it. You can speak of seeing red and yellow in orange, meaning that you see the resemblance of orange to both red and yellow, but as you look at the orange color you do not actually see a good red and a good yellow. The red and yellow are so perfectly blended in the orange as to lose their own specific qualities, and the orange has a specific quality all its own. In this respect all colors are equally elementary.

But some colors are more salient or outstanding than others. White and black are the clearest examples. They are the extremes in the white-black series of grays, and there is no gray in the series that stands out above the rest. If the hues are arranged in a circle, red, yellow, green and blue stand out and might well be made the corners of a square diagram to be substituted for the circle.

It would seem reasonable to conjecture that the salient colors are also primary and that all the other colors are derived from them by combination. At least, we may reasonably suppose that the retina has just a few primary activities which go on together in varying proportions and give numerous resultant effects. The search for primary colors has proved very fascinating to psychologists and sense physiologists—fascinating and productive of opposing theories.

The facts of color mixture suggest a very small number of primaries, since all the hues, and also white and gray, can be obtained by mixing four wave lengths corresponding to red, yellow, green and blue. Moreover, you do not need the yellow, since you can get it by mixing red and green. All the colors, including white, can be got by mixing red, green and blue. This striking fact is the basis of the well-known Young-Helmholtz (7) theory of color vision, which supposes that there are just three primary responses of the retina to light, giving the sensations of red, green and blue.

This theory has some difficulty in explaining the facts of color-blindness, next to be considered.

Color-blindness. There are two kinds of color-blindness, total and partial. *Total color-blindness* amounts to rod vision, which gives light and dark, but none of the spectral colors. The outermost zone or ring of the retina, where cones are very scarce, is almost totally color-blind. Some individuals, very few, are totally color-blind over the whole retina, having apparently no cones but only rods; their vision is poor, as would be expected.

With regard to color theory, we learn from total color-blindness that colorless sensations are not necessarily combinations of red, green and blue, since they occur when those color responses are not in the individual's power. Rod vision is certainly more primitive than cone vision, and we thus get the suggestion that white-black-gray vision is more fundamental than red-yellow-green-blue vision.

Red-green blindness, though very uncommon among women, is present in 3 or 4 percent of men. It is not a disease, and is not associated with any other defect of eye or brain. Nor can it be cured or corrected by training. It is simply a hereditary peculiarity of the color sense, a reduced or simplified form. The red-green blind individual, as we learn from a few individuals who are red-green blind in one eye and have normal color vision in the other eye, has the sensations of yellow and blue, along with white, black and the grays—but no red or green. What appears to the fully equipped eye as red or green appears to him as dull yellow, and what appears to the normal eye as greenish blue, violet or purple appears to him as dull blue. He has difficulty in picking strawberries, in obeying the traffic lights, and in selecting his neckties.

Now everyone is red-green blind in the intermediate zone of the retina, between the central region which has full color sense and the outermost zone which is almost totally color-blind. This statement can be checked by taking bits of various colors and moving them slowly from the very margin of the field of view towards the center, all the while keep-

ing the eyes directed straight ahead. When the bits first become visible, at the margin of the field of view, they have no color other than gray, then they take on a blue or yellow tinge, and finally, near the center of vision, they acquire their red or green components and show in their true colors.

These "zones" are not sharply separated. An intense, saturated color can be recognized farther out from the fovea than a weak color. At high intensities red, yellow and blue are perceived even out to the periphery of the field of vision.

Red-green blindness is really yellow-blue vision. This fact is not readily harmonized with the Young-Helmholtz theory, since the yellow sensation is had under conditions when the red and green sensations are impossible. The facts seem to be summed up better by the Ladd-Franklin theory (*10*). This theory treats of the color sense as having passed through three stages of development. In the earliest stage the only primaries were white and black; in the second stage the white primary split into one for yellow and one for blue; and in the third stage yellow split into red and green. The outermost zone of the retina is still mostly in the first stage, and the intermediate zone in the second, the central retinal area having reached the final stage. In red-green blind individuals, the central area remains in the second stage, and in the totally color-blind the whole retina is still in the first stage. There is evidence that some animals normally remain in the first stage, and some in the second.

A word should be added about *black*. Black is sometimes said to be simply the absence of light. But black is as positive a sensation as any. We even speak of an "intense black." Black is a response made to the absence of light, but it occurs in its full intensity, as absolute black, only just after light is withdrawn from the eye, or else in an unlighted area surrounded by light.

After-images. A better name would be *after-sensations*. Any response outlasts its stimulus. This is true of a muscle, and it is true of a sense organ. The ear is very quick in recovery, and gives almost no after-sensations, but touch after-sensations can easily be felt after a momentary touch

on the skin. Visual after-sensations are the most interesting. If you look towards a lamp, but with a book in front of your eyes to serve as a screen, remove the screen for an instant and then replace it, you continue for a short time to see the light after the stimulus is cut off. This *after-lag* is like the main sensation, only weaker. The *after-image* can be obtained by looking steadily at a black-and-white or colored figure for fifteen seconds, and then looking at a gray background. After a moment's delay, an after-sensation develops in which black takes the place of white and white of black, while for each color in the original the complementary color now appears. When so appearing, the after-image is "negative," but it can be transformed into a positive by closing the eyes or turning them upon a black background. After strong stimulation the after-image may last for a long time and be switched back and forth repeatedly between the positive and the negative. The colors, however, are rather undependable. The after-image of a bright white light may go through a long sequence of different colors before it disappears.

Visual contrast. Contrast is another effect that occurs in other senses, but most strikingly in vision. After looking at a bright surface, one of medium brightness appears dark, while this same medium brightness would seem bright after looking at a dark surface. After looking steadily at one color, and then turning the eyes upon the complementary color, the latter appears more saturated than usual; in fact, this is the way to secure the most saturated color sensations—it is worth trying. These effects of adaptation are also called "successive contrast."

"Simultaneous contrast" is peculiar to the sense of sight. If you take two pieces of the same gray paper, and place one on a black background and the other on white, the one on black looks much brighter than the other. Spots of gray on a colored background are tinged with the complementary color. Any two adjacent colors produce contrast effects in each other, though we do not usually notice them any more than we notice the after-images which surely occur many

times in the course of a day. We disregard sensations that do not indicate objective facts.

Before coming to grips with the question how we perceive objective facts by use of the patches of colored light in the retinal picture, we need to complete our study of the organ of vision by taking account of eye movements and binocular vision.

Eye movements. The eyeball is turned in its socket by six muscles, and the two eyes are so harnessed together in their motor nerve centers that they show almost perfect teamwork in their movements. They execute two types of coordinated movement. In looking here and there about the landscape, the two eyes turn together like a pair of horses, and this is the *conjugate* movement of the eyes. But in turning from a far to a near object, the eyes are brought from a parallel position into one of *convergence*, such that the foveas of both eyes receive the light from the particular object looked at.

The conjugate movement, on being recorded photographically (*2*), is found to have two varieties, called the jump or *saccadic* movement and the *pursuit* movement. The saccadic movement carries the eyes from one object to another, while the pursuit movement follows a moving object.

Watch the eyes of someone who is looking at a scene and you will see them jumping from one part of the scene to another. The eyes fixate one point for a short time, jump to another point and remain there for a moment, and so on about the field of view. In reading, as the result of practice, the eyes follow a more regular procedure, fixating a series of points in a line of print, with short jumps from each fixation point to the next, and a longer reverse jump to the beginning of the next line. As each jump occupies but a thirtieth to a fiftieth of a second, while the fixation pauses between jumps last much longer, the result is that over 90 percent of the time spent on a line of print is fixation time, less than 10 percent being consumed in making the jumps. It has been found that nothing of any consequence is seen during the jumps, and that the real seeing takes place only during the

fixations. The saccadic movement is simply a means of passing from one fixation to another with the least waste of time.

The eye sees an object distinctly only when stationary with respect to the object. If the object is still, the eye must be still. But if an object is moving with moderate speed, the eyes can keep pace by a pursuit movement, so remaining fixed upon the moving object, and getting a clear picture of that object, while the stationary background is reduced to a blur.

Binocular vision. In most animals, the eyes look to the side, and have different fields of view, and their combined fields compass almost the entire horizon. Though we can see the utility of this sort of binocular vision, it is difficult for us to imagine what it would be like, since the human eyes are located close together, looking forward, receiving almost the same stimulation, and functioning as a single organ. How does this type of binocular vision differ from monocular vision, and what advantage does it have?

Two eyes are an advantage in near vision because they then get *slightly different views* of the same object. The right eye sees a little more around to the right of a solid object held in the hands, and the left eye a little more around to the left. Thus the solid object is more completely seen at any one moment with two eyes.

More important, the brain responds to these slightly different simultaneous views of the same object, delivered by the two eyes, by not only seeing more of the solid object, but also seeing the solidity of it, its third dimension.

Among man's special characteristics, which make his behavior different from that of animals, are the erect posture, freeing the hands for manipulation of objects, the development of the hand as a manipulatory organ, and the forward position of the eyes, which affords a three-dimensional view of objects as they are manipulated. Thus the human type of binocular vision fits in beautifully with man's manual dexterity and with his attentiveness to objects which can be handled. Binocular vision reveals the third dimension also in

objects that are somewhat farther off, up to a hundred feet or more. But, being close together, the eyes get essentially the same view of any distant object, so that the solidity effect of binocular vision is lost.

The *stereoscope* is a convenient instrument for experimenting upon binocular vision. It presents separate views to the

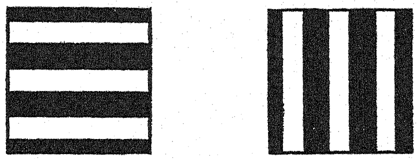

FIG. 93.—Binocular rivalry. Even without the aid of a stereoscope, different fields can be presented to the two eyes. Hold the page a few inches from the eyes, so that one square shall be before the right eye and the other square before the left eye; and let the eyes relax with no effort to see distinctly. The two squares should be superposed and seem to be in the same place. Hold this position, staring steadily and passively, and watch for any shifting of the appearance, from horizontal to vertical bars and back. See also the Frontispiece.

two eyes. If the views show the same object or scene, photographed from two positions close together, the third dimension comes out very realistically. If radically different figures or colors are presented to the two eyes, by aid of the stereoscope, the usual result is *retinal rivalry*. First what is before one eye is seen for a time, then what is before the other, and so on alternately—as if the brain were unable to make any synthesis of the two discrepant images, and had to accept the one or the other at any moment. However, sometimes other results occur. A red before one eye and a yellow before the other may be seen as orange (binocular color mixture), and a bright red before one eye and bright green before the other are sometimes, not often, fused into yellow, or a yellow and blue into white (*6*).

VISUAL PERCEPTION

When you look out of the window on even the most ordinary scene, what you see is simply astounding. It is so to a psychologist. You see objects of various shapes, sizes and

colors, lying at different distances, some of them in sunlight and some in shadow. What is there strange about all that? The strange thing is the great divergence between this objective situation and the medley of juxtaposed color patches, differing slightly from one eye to the other, which is all your retinas get from the environment and all they furnish the brain as signs of the objective facts. Move about a little while watching the scene; you see constant motion in the visual field—in the picture, we may call it—yet the objects do not seem to move. Look at a near-by object like a table or chair from different positions, and the picture is very different; yet the object looks the same. The stimuli change but the appearance remains the same. Things appear to the observer as they are objectively, not as they are pictured on the retina.

That there is a problem here will be brought home to anyone who, without previous experience in drawing or painting from nature, attempts to reproduce the picture his eyes give him. Like the child or the primitive artist he will doubtless try to put on the canvas what he sees to be out there in space. The realistically inclined painters struggled for centuries to discover what was in the picture, as distinguished from what was out there in space. Their job was to put on canvas, as far as possible, the same aggregate of color patches as the scene presents to the retina. Instead of interpreting the stimuli from the objects, as we do in practical life, the painter has to disregard the objects and reproduce the stimuli.

Seeing distance or the third dimension. The stimuli received from the environment are spread out in two dimensions on the retina like a picture projected upon a screen. The picture has the left-right and up-down dimensions, but no front-back dimension. How then does it come about that we see the distance of objects from us, and the solidity and relief of objects? This problem in visual perception has received much attention and been carried to a satisfactory solution.

A single, motionless eye receives a picture similar to one painted on canvas, and the available indications of distance

are the same in the two cases. The painter uses *perspective*, or foreshortening, and makes a man the smaller in the picture the farther away he wants him to appear; and in the same way, when any familiar object casts a small picture on the retina, we perceive the object, not as diminished in size, but as far away. The painter colors his near hills green, his distant ones blue, and washes out all detail in the latter—*aerial perspective*, he calls this. His distant hill peeks from behind his nearer one, being partially *covered* by it. His *shadows* fall in a way to indicate the relief of the landscape. These signs of distance also affect the single eye and are responded to by appropriate spatial perceptions.

With both eyes directed on a real scene, we have the *binocular depth effect*, just described, which the painter cannot use. This is a realistic appearance of solidity in three dimensions, provided the object examined is near. A little experiment demonstrates the superiority of binocular over monocular vision in the perception of distance. Take a pencil in each hand, close one eye and bring the pencil points horizontally from the two sides till they seem to be almost touching; then open the other eye, and see if you can improve the setting.

Another binocular sign of distance is afforded by *double images*. When the eyes are converged on a near point, more distant objects are seen double; and when the eyes are directed to a distant point, nearer objects are seen double. Hold a pencil about a foot in front of the nose, directly in line with some more distinct object. When you look at the pencil you see the farther object double, and when you look at the farther object the pencil is seen double. These double images usually remain unnoticed but help greatly in perceiving the relative distances of objects in the field of view.

If the head is moved from side to side, while the eyes continue to look forward, distant objects seem to move with the head, and nearer objects to slide in the opposite direction. Try this in the woods some time, and see how clearly the nearer and farther branches are distinguished. If you look

to the side from a rapidly moving train or car, the effect is still more pronounced.

All these signs of distance are utilized together in the visual perception of three-dimensional space, sometimes one sign and sometimes another being more useful. In learning the spatial meaning of these signs, the child is undoubtedly helped by watching objects as they approach or recede from him, or as he approaches them. The chick reacts correctly to distance as soon as hatched, and it is quite possible that some sign of distance, probably the binocular sign, does not have to be learned.

Erect vision in spite of the inversion of the retinal picture. The picture thrown upon the retina by the lens of the eye is upside down—a fact that formerly caused much fruitless speculation as to how we can see the field of view right side up. Stratton (*13, 14*) prepared a system of lenses that re-inverted the field of view, and wore this device constantly for a week, except at night when he was blindfolded. The lenses reversed right and left as well as up and down. The field of view was of course not distorted as a picture, and the eye and head movements of looking towards a seen object were not disturbed. But the relation of the visual field to hand, foot and body movements was reversed, with great resulting disturbance of movement and orientation. At first, movements in response to seen objects were entirely false; the subject reached in the wrong direction for any seen object, and ran into anything that he tried to avoid. Movements guided by the eye were laborious and nerve-racking, and had to be performed either by patient calculation or else by mere trial and error. By the end of the week, the subject was able to walk freely about the house, and to perform all sorts of manual operations, and his behavior in familiar surroundings became almost normal, though the field of view still did not appear right side up. When he removed the lenses at the end of the week, the first effect was one of pleased surprise at finding himself back in his old, familiar visual space; but there was considerable bewilderment and movements were false again, since they continued to follow the new system

of eye-hand co-ordination. After a few hours, however, the old system was fully re-established. Erect vision, according to the results, must be largely a matter of integration between vision and movement (*3*).

Visual perception of object size and shape. A novice in drawing or painting from nature has difficulty in representing the shapes and relative sizes of objects. He *sees* two men to be of the same height when one of them is standing ten feet from him and the other twenty feet; but if he makes them of the same size in his drawing, something is wrong. His teacher shows him how to measure the picture size of objects by extending his arm, holding a pencil upright and marking off the intercepted height of the object with his thumb; and he then finds that the man who stands farther away has much less height in the field of view and should be correspondingly diminished in the picture. Picture size or stimulus size depends on the real size of the object and on its distance from the observer.

It is the same with the shape of objects. A novice seeing a circle draws it as a circle, while according to the stimulus received it is an ellipse unless it chances to be seen square on.

In looking at a real scene the observer uses the signs of distance which have been mentioned and perceives the spatial relations in the objective situation and the relative distances of the various objects. His adjustment to these spatial relations is part of his situation set. Each particular object fits into this general framework. As he looks at an object he sees its distance and he has given its stimulus size or size in the "picture." Since he is set for the distance of the object, its picture size immediately *means* its real size.

However, the observer is not likely to be perfectly accurate in his perception of the real sizes of objects at various distances. He may not allow adequately for their distances. In an experimental test of this matter, the subject looked down a long table and saw two circular gray disks, one 5 feet away, the other 10 feet. The nearer one was 4 inches in diameter, the farther one might be larger or smaller. The subject was asked which disk looked larger, and the farther

disk was changed till the size was found that looked the same as the nearer one. Exact equality of real size would of course require the farther disk to have a diameter of 4 inches, while exact equality of stimulus size would demand a farther disk of 8 inches diameter. The 25 women college students who took this test varied somewhat but their average choice for the far disk was 4½ inches, very close to objective equality though with a slight compromise effect (*12*).

Perception of object colors. We return now to the problem in color perception that was raised at the beginning of the chapter. How can the observer see objects in their real colors in spite of the various illuminations in which they may stand? If a white cow goes out of the sun into the shade of a tree, she does not seem to our eyes to change color. A black cow in the sun still looks black, though more light is reaching our eyes from her black surface than from the white surface of the other cow standing in the shade. To a remarkable degree we are able to identify the color of an object in spite of changes in the illumination. This fact is known by the name of "color constancy," meaning the constancy of object color as perceived (*9*, *11*).

If you take two sheets of the same paper and place one near the light and the other far from the light, the latter is more dimly illuminated and consequently reflects less light to the eye, as you can easily verify by holding the near sheet so that it partly overlaps the farther one in your field of view. Nevertheless you have no difficulty in seeing that both sheets are of the same color as pieces of paper. This experiment has been tried out systematically on children and adults, who were asked to match various shades of gray, always matching a well lighted with a dimly lighted specimen. As the gray papers were alike in all other respects, they could be matched only by their shade. The matching was accomplished readily and with little error even by four-year-olds (*1*). In accurate tests, individuals are found to differ somewhat and color constancy is seldom perfect, the usual match being a compromise between the stimulus color and the object color (*8*, *12*).

The psychological problem is fundamentally the same here as in regard to perceiving object size. We wish to discover how the observer is able to read off the approximate color of an object instantly, whether it stands in good light or shadow. We must first ask what it is that he perceives.

What object colors are, physically. A white object or substance is one that reflects all the light it receives, absorbing none, and a black substance is one that absorbs all and reflects none. (These are the "ideal" white and black; a good white paper does absorb some of the light, about 20 percent, reflecting 80 percent, and a good black paper reflects about 5 percent of the light.) A dead gray object absorbs some fraction of the light, and absorbs it unselectively, all wave lengths alike. A colored object is one that absorbs the light selectively, and therefore reflects selectively; a red object reflects the red rays predominantly, and a blue object the blue. The surface of any object is a light filter; a white surface sends all the light back unchanged; a black surface kills the light, and a gray partially deadens it; a red surface reddens the light; and so on. When we perceive object color, it is this physical property of the object which we perceive.

Taking account of the illumination. It is easy to prove that object color cannot be perceived unless the observer is enabled to allow for illumination.

The simplest way of concealing the illumination conditions is to look at a plain surface through a tube or "hole screen." Roll a paper tube small enough so that on looking through it you can see only a single uniform surface. Or cut a hole in a sheet of paper and hold it a few inches in front of the eye. It is not always possible to find perfectly plain surfaces to examine, but if such a surface is examined through the tube it loses its object character and the visible spot is seen simply according to its stimulus color.

From what has been said of the physical fact of object color, we see that the observer could arrive at that fact by deduction from two given facts, the illumination received by an object and the stimulus reflected by that object to the eye. If the observer saw the light reflected from the object to be

the same in color and brightness as the illumination, he could infer that the object was white. If he saw the light reflected to be redder than the illumination, he could infer that the object was red. The observer does not actually go through any such process of reasoning and calculation, but he sees object colors instantly—actually *sees* them—provided the illumination is sufficiently revealed.

The set for illumination. There are several good indications of illumination: the general brightness and color of the field, the shadows and high lights, and the minute shadows and high lights on a rough surface. These are all seen in relation to the space characters of the visible field of objects. Under normal conditions the observer promptly becomes set or adjusted for the illumination, and consequently does not need to reason out the color of an object. He receives the light from the object while set for the total situation, illumination included. The principle is the same as in perceiving object size. There, one is set for the distance of the object and reads off the object size from the stimulus size. Here, one is set for the illumination and reads off the object color from the stimulus color.

Seeing movement. Motion in the field of view is easily seen, and fully as easily in indirect as in foveal vision. Part of the utility of the external zones of the retina is their ready picking up of any movement and arousing an eye jump which brings the fovea to bear on the moving object.

Motion pictures set an interesting problem in the perception of movement. What is projected on the screen is a series of still pictures, a series of instantaneous snapshots, no single one of which shows any motion. Whence comes the motion that you see in looking at this series of motionless views? Evidently the seen motion is your response. The film has enough in common with an actually present moving object to arouse the same perception.

The after-lag of visual sensation quite obviously plays a part here, for without it the picture would be seen to be intermittent, as it is physically. But a more important factor is that the brain is tuned to see motion, and grasps at any

chance to see it. It sees motion much more readily than it can pick out the successive positions through which a moving body passes. Everyone who has examined snapshots has been surprised at the queer positions into which a man, or a horse, gets in the course of his movements. We can scarcely believe that he actually takes these positions. We perceive the movement as a continuous pattern, but we do not perceive the consecutive positions (p. 39).

Apparent movement can be seen with much simpler stimuli than those of the moving pictures. All you need is two lines, a short distance apart, presented one after the other to the eyes with a little blank interval between them. You can try the experiment by simply holding the forefinger upright three or four inches in front of the nose, and looking at it while winking first one eye and then the other. To the right eye it appears more to one side and to the left eye more to the other side; and when one eye is closed and the other simultaneously opened, the finger seems actually to move from one position to the other. This result is confirmed by careful laboratory experiments. If the time interval between the exposures of the two lines is very short, the lines are seen as present together, each in its own position; and if the interval is rather long, one line is seen in its position and then the other in its position, without apparent motion. But if the interval is just right, movement appears (*4, 5*).

Motion pictures are based on the proneness of the organism to see movement patterns rather than successions of discrete stimuli. They afford a striking example of the tendency to see objects and their behavior and not simply to see the light by which the objects are revealed.

Summary of the chapter. Under the head of visual sensation we examine the response of the eye and brain to changes in the stimulus of light. The retina contains two kinds of receptors: the cones which give form and color vision, and the rods which give no color vision and are not very acute in regard to form but which become adapted to very faint light during a prolonged stay in the dark. In color vision

we have the dimensions of brilliance (brightness) dependent on the intensity and also on the wave length of the light; hue, dependent on the wave length; and saturation, dependent on the amount of mixture of different wave lengths. By combining different wave lengths on the retina we obtain color blends and find that all hues, including white, can be obtained by mixture of three colors, red, green and blue. It is not quite certain that these three are the only primary colors, for yellow is seen in color blindness when red and green are not seen as distinct hues. Visual contrast and after-images are striking phenomena, once you have your attention on them. Binocular vision is important in seeing the third dimension.

Under the head of visual perception we ask how the individual is able to see objective facts such as the size, shape, distance and color of objects. The painter is concerned to discover the signs of these facts so as to produce a realistic effect from an assemblage of color patches on his canvas. He uses perspective, etc., to indicate distance. When the observer gets the distance of an object from the signs of distance, he reads off the real size of the object from its size in the picture (on canvas or on the retina). When he sees the conditions of illumination he reads off the color of an object from the stimulus received from that object. That is, when he is set for the situation as a whole, he sees the objects in it accordingly, though usually with some little error.

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Chapter XV

The Other Senses

THOUGH sight is perhaps the most important of the senses to human beings, as well as the most thoroughly studied, there is much scientific information available regarding the other senses, and each of them has important contributions to make to the life of the individual and to his adjustment to the environment.

Problems in the study of the senses. As in the case of vision, the study of any sense includes two main problems. (a) The problem of sensation concerns the correspondence of the individual's impressions with the *stimuli* he receives. The task is to arrange the multiplicity of sensory experiences in some kind of order, to identify salient and if possible primary sensations and to correlate them with their respective stimuli. (b) The problem of perception is that of discovering what use is made of each sense in knowing the environment; the question concerns the correspondence of the individual's impressions with *objects*.

The sense organs in general. The most primitive animals, the protozoa, though sensitive to various stimuli, are sensitive all over, rather than in certain spots. They respond to mechanical stimuli (contact or jarring), to certain chemical stimuli, to thermal stimuli (heat or cold), to electrical stimuli and to light. They have no special light-sensitive spot, but respond to light no matter where it strikes them.

In the development of the metazoa, or multicellular animals, specialization has occurred, some parts of the body becoming muscles, some parts digestive organs, some parts conductors (the nerves) and some parts specialized receptors or

sense organs. A sense organ is a portion of the body that has very high sensitivity to some particular kind of stimulus. The eye responds to very minute amounts of energy in the form of light, but not in other forms; the ear responds to very minute amounts of energy in the form of sound vibrations, the nose to very minute quantities of chemical energy.

A useful classification of the senses divides them into the exteroceptors, the interoceptors, and the proprioceptors. The exteroceptors receive stimuli from outside the organism, the interoceptors from the interior of the mouth, throat, gullet, stomach, intestines and lungs, while the proprioceptors are located in the proper substance of the body, i.e., in the muscles, tendons, joints, bones, etc., and are stimulated by movements of these parts. Of the exteroceptors, the eye, ear and nose are singled out as *distance receptors*, because they receive stimuli from sources that are not in contact with the organism. The distance receptors enable the organism to adjust itself to a wide environment.

Mechanism of a sense organ. Each sense organ is a receiving instrument or indicator, as the thermometer is an indicator of temperature. The sensitive part of a sense organ is not visible from outside, but lies in the depth of the organ—that for smell being well back inside the nose and that for hearing, the inner ear, being embedded in the bone beneath the external ear. Each sense organ has its *sensory nerve* which connects it with the nerve centers and through them, indirectly, with all parts of the body. Without this nerve connection the sense organ could have no influence on the activities of the organism. The axons of the sensory nerve divide into fine branches within the sense organ, and the high sensitivity of the organ is partly due to these fine nerve endings. In addition, there are special *sense cells* in the eye, ear, nose and mouth. Besides these sensitive structures most of the sense organs contain *accessory apparatus* which conveys the stimulus effectively to the nerve endings and sense cells. The lens, the iris and the muscles of the eye belong in the category of accessory apparatus.

The excellence of a receptor depends (a) on its being

selective, tuned to one kind of stimulus, and not indifferently responsive to every stimulus, (b) on its being very *sensitive* to its particular kind of stimulus, (c) on its responding differently to different *intensities* of the stimulus, and (d) on its responding differently to different qualities or *varieties* of the stimulus. For example, the sense of smell is selective in that it responds to odors and not also to sounds entering the nose—which would be confusing; it is sensitive in that it indicates the presence of incredibly small quantities of an odorous substance in the air; it responds differently to faint and strong odors by smell sensations of different intensities; and it gives different smells according to the odorous substance. Few man-made instruments can vie with the nose in these respects—or with the eye and ear.

THE SKIN SENSES

Moist and dry, hot and cold, itching, tickling, pricking and stinging are skin sensations; but some of them are certainly complex. Relatively simple sensations are obtained by exploring the skin, point by point, with weak stimuli. As a cool stimulus, a pencil point at room temperature will serve for a hasty exploration. Passing it lightly along the skin, one gets at most points merely a sensation of contact, but at certain points there is a clear cold sensation. Within any half-inch square on the back of the hand, several of these *cold spots* can be found, and painstaking work, with adequate apparatus and procedure, shows some of them to be permanent. Similarly, *warmth spots* are located by using a stimulus a few degrees warmer than the skin. If a sharp point is pressed moderately against the skin, it gives at many places a small, sharp pain. These are the *pain spots*. Finally, if the skin is explored with a hair of just the right flexibility, nothing at all is felt in most places, but at some points there is a definite sensation of touch or contact; and these are the *touch spots*. The pain spots and touch spots are much more numerous than the temperature spots, and of these, the cold spots are more numerous than the warmth spots.

As no further varieties of sensory spots are found, touch, warmth, cold and pain are believed to be the only primary cutaneous sensations. Itch, stinging and aching seem to be variations of pain. Tickle seems to be a variety of touch.

Hard and soft combine touch from the skin with resistance encountered by the muscles and detected by the muscle sense. They are qualities of objects rather than of stimuli and are perceived rather than sensed. Somewhat the same is true of rough and smooth, which are felt by moving the skin over a surface and so obtaining a vibratory stimulus (*9*).

The elementary stimuli of the skin senses. The question is exactly how the skin is acted on to give each primary sensation. In the case of *touch*, the exact stimulus is a bending of the skin, either in or out, at any touch spot, or at many touch spots at once. The stimulus that gives *pain* may be mechanical (as a needle prick), or thermal (heat or cold), or chemical (as a drop of acid), or electrical; but in any case it must be strong enough to injure or almost injure the skin. The pain receptors, then, are not highly sensitive, but require a fairly strong stimulus; their use is to detect the presence of stimuli that threaten injury.

Temperature stimuli require more discussion. The internal body temperature is steady, in health, at about 98° Fahrenheit, but the surface of the skin is likely to be about 85-90°, which feels neither warm nor cool, because neither the warmth nor the cold spots are aroused. They are "adapted" to skin temperature. Let a metal object, or other good conductor of heat, be laid upon the skin. If the metal object is warmer than the skin, it will raise the surface temperature. If the stimulus is a single degree above the skin temperature, it will feel warm—or cool, if a single degree below. Regarding the organism as a thermometer, we may say that its zero lies at skin temperature, and that its sensitiveness is very good for temperatures just above or below its zero.

This psychological zero shifts up and down according to the temperature of the skin. Immerse the hand for five minutes in water at any temperature between about 60° and 100° F., and you change the skin temperature and the zero

point to correspond. Objects a degree or two warmer or cooler than the new zero will give the warm or cool sensation. Beyond the limits mentioned, the temperature sense cannot fully adapt itself (3).

There is an old and striking demonstration of temperature sense adaptation—a rougher form of the experiment just described. Take three bowls of water, one at skin temperature

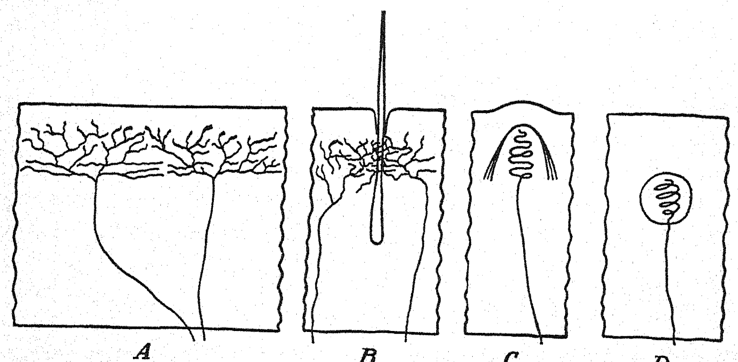

FIG. 94.—Diagrammatic views of skin receptors:
A, the most common type, present throughout the skin.
B, the hair as a sense organ.
C, a touch corpuscle, from the finger tip.
D, an end-bulb, from the mucous membrane. Several other varieties of end-bulbs are found in the mucous membrane, the surface of the eyeball, the subcutaneous tissue and elsewhere.

and seeming neither warm nor cold, one definitely hot and one definitely cold. Hold one hand in the hot water and the other in the cold, for half a minute, and then plunge them both into the medium water, and you will find the latter to feel warm to the cold-adapted hand and cold to the warm-adapted.

The organism as a thermometer gives more than the simple fact that an object is above or below skin temperature. With colder and colder objects, it gives increasing intensities of the cold sensation, till finally the pain sense is aroused. With objects above the psychological zero, it gives increasing intensities of the warmth sensation, and finally burning heat.

The touch sense, as well as the temperature senses, shows the adaptation effect. A perfectly steady pressure on the skin

soon ceases to be felt. Pull on a glove and hold the hand perfectly quiet (so as to avoid changing the pressures), and you soon cease to feel the glove.

The skin receptors. Innumerable sensory nerve fibers grow out to the skin, where each one divides into many fine branches. Not in the outermost, horny layer of the skin, but just a little way in, is a perfect forest of fine nerve branches. On hairy parts, the hairs extend down into the forest of nerve ends in the skin and, when touched on the outside, act as little levers in stimulating the nerve ends. They are accessory apparatus to the sense of touch.

On hairless surfaces, especially the palms, some of the sensory nerve fibers terminate in little cones of tissue within the skin, and these "touch corpuscles" are believed to be touch receptors. Spherical end-bulbs, which are minute round or oval bodies, with a sensory nerve fiber terminating in each of them, are probably cold receptors, but are not known to occur in the external skin.

Sensory nerve endings are present not only in the skin but also in the subcutaneous tissue, and deep pressure and dull pain can be felt even when the skin is anesthetized. Cutaneous sensation extends into the mouth and nose, and the tip of the tongue is a keen touch organ, but on the whole these extensions of the skin senses are less keen than the skin itself. As everybody knows, the skin is much keener in some parts than in others, and the four skin senses vary independently from part to part, one region being especially sensitive to cold, another to warmth, another to touch and another to pain stimuli.

We speak nowadays of the "four skin senses" rather than of a single sense of touch. With such radically different stimuli, mechanical and thermal, and with the radically different sensations of warmth, cold, pain and touch, we are justified in speaking of different senses even though it is not yet clear whether each of them has a distinct form of receptor.

THE MUSCLE SENSE

The muscle sense was the "sixth sense," so bitterly objected to in the middle of the nineteenth century by those who maintained that the five senses that were good enough for our fathers ought to be good enough for us, too. The ques-

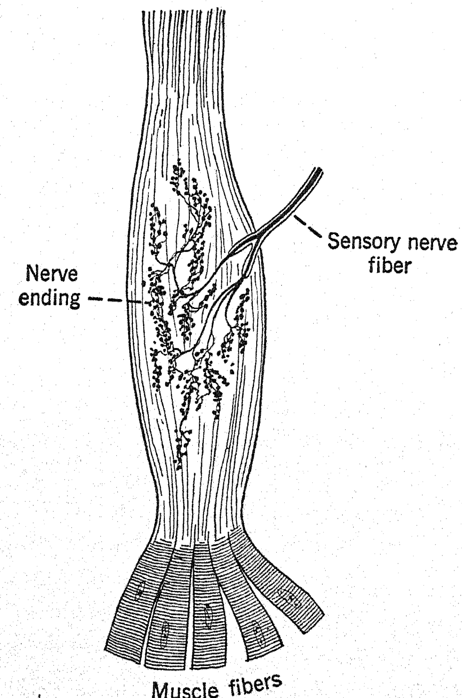

FIG. 95.—(Ramon y Cajal.) A tendon spindle, similar to the muscle spindle mentioned in the text, but found in the tendon instead of in the muscle substance. When the tendon is made taut by the contraction of its muscle, the nerve endings are squeezed and stimulated.

tion was whether the sense of touch did not account for all sensations of bodily movement. It was shown that there must be something besides the skin sense, because weights were better distinguished when "hefted" in the hand than when simply laid in the motionless palm, and because the co-ordinated movements of a limb were much more disturbed by loss of *all* its sensory nerves than by loss of its cutaneous

nerves alone. Later, the crucial fact was established that sense organs (the "muscle spindles") existed in the muscles, and other sense organs in the tendons and about the joints. This sense is the muscle, tendon and joint sense rather than simply the muscle sense. It is sometimes called the *kinesthetic* sense, from the Greek words meaning "sense of movement."

This sense is stimulated by muscular movements, by postures, by passive movements and by external resistance encountered by a movement. It furnishes important information regarding the weight of objects, their firmness or looseness, hardness or softness, stiffness or flexibility. The muscle sense and the sense of touch, working together, enable us to recognize an object and perceive its size and shape by feeling of it with the hand.

The muscle sense is important in either reflex or voluntary movement. Without it, when you wanted to start any movement, you would have little indication of the existing position of the limbs; and when the movement was on the way, you would have little indication of how far it had progressed and would not know when to stop it. Locomotor ataxia, a disease characterized by unsteady posture and poor control of movement, is primarily a disease of the muscle sense nerves.

ORGANIC SENSATION

The term "organic sensation" is used to cover a variety of sensations from the internal organs, such as hunger, thirst, nausea, suffocation and the vague bodily sensations that color the emotional tone of any moment. Hunger is a sensation aroused by the rubbing together of the stomach walls when the stomach, being ready for food, begins its churning movements. Systematic exploration of the internal organs reveals astonishingly few sensations arising there, but there can be little doubt that those just listed really arise where they seem to arise, in the interior of the trunk.

THE SENSE OF TASTE

A simple experiment shows that the numerous so-called tastes of daily life are not tastes in any exact sense. The subject holds his nose, so as to prevent any odor from reaching the olfactory receptors, and when thus limited to the sense of taste alone is unable to distinguish coffee from a weak solution of quinine, or apple juice from onion juice. Coffee and quinine have the bitter taste in common, and that is all the taste they have; onion and apple have the sweet taste in common. The primary tastes are limited to *bitter, sweet, sour and salty* (7).

The interior of the mouth is supplied with the skin senses as well as with taste. A biting "taste" is partly pain, and a smooth "taste" partly touch sensation. The temperature of a food or drink also contributes to what we inaccurately call its taste. In addition to all these sensations from the mouth, food in the mouth stimulates the sense of smell by way of the throat and the rear passage to the nose; and the *flavor* of food consists largely of odor.

Analysis of tastes, like that of skin sensations, is greatly assisted by the fact that the different sensations are aroused by stimulation of different spots. Some of the papillae or little protuberances on the surface of the tongue contain taste receptors, and correspond to the spots of the skin, with this difference, that few of the papillae give a single taste sensation. Some give only two or three of the four primary tastes; and the bitter taste is got principally from the rear of the tongue, sweet from the tip, sour from the sides, and salty from the tip and the adjacent part of the sides. A sweetened bitter solution tastes sweet when applied with a little brush to the tip of the tongue, and bitter when applied to the rear of the tongue.

The actual taste receptors, called taste buds, are located not on the surface of the tongue, but in little pits which extend down from the surface. The taste buds are bunches of sense cells, each cell having a slender tip that projects into the pit, where it is exposed to the sugar or salt or other tasting sub-

stance present in the mouth. The sense cell, being thus aroused to activity, arouses in turn the fine branches of the sensory nerve fiber which twine around the base of the cell. Thus a nerve current is started along the sensory nerve to the brain.

The stimulus to the sense of taste is of a chemical nature. The tastable substance must be in solution in order to pene-

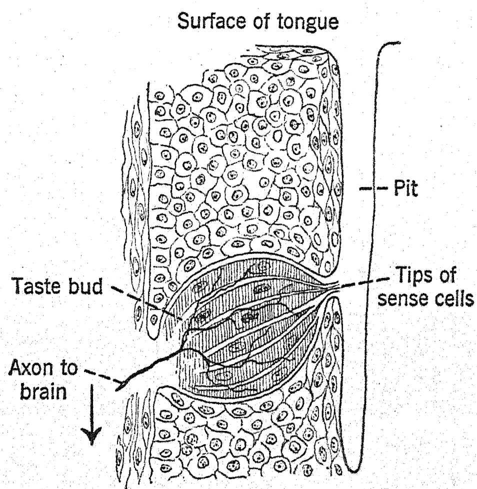

Fig. 96.—A taste bud, showing its location and nerve supply.

trate the pits and reach the sensitive tips of the taste cells. If the upper surface of the tongue is first dried, a dry lump of sugar or salt laid on it gives no sensation of taste until a little saliva has accumulated and dissolved some of the substance.

Exactly what the chemical agent is that produces a given taste sensation is a problem of some difficulty. Many different substances give the sensation of bitter, and the question is what there is common to all these substances. The sweet taste is aroused not only by sugar, but also by glycerine, saccharine, and even "sugar of lead" (lead acetate). The sour taste is not aroused by all acids, and is aroused by some substances that are not chemically acids. The chemistry of taste stimuli is not yet fully understood.

Though there is this uncertainty regarding the stimulus, on the whole the sense of taste affords a fine example of success achieved by experimental methods in the analysis of complex sensations. At the same time it affords a fine example of the fusion of different sensations into characteristic *blends*. The numerous "tastes" of everyday life, though found on analysis to be compounded of taste, smell, touch, pain, temperature and muscle sensations, have the effect of units. The taste of lemonade, for example, compounded of sweet, sour, cold and lemon odor, has the effect of a single characteristic sensation. It can be analyzed, but ordinarily it appears as a unit.

THE SENSE OF SMELL

The great variety of odors has proved very difficult to reduce to order. The olfactory receptors are so secluded in their position, in a little alcove back in the nose, that they

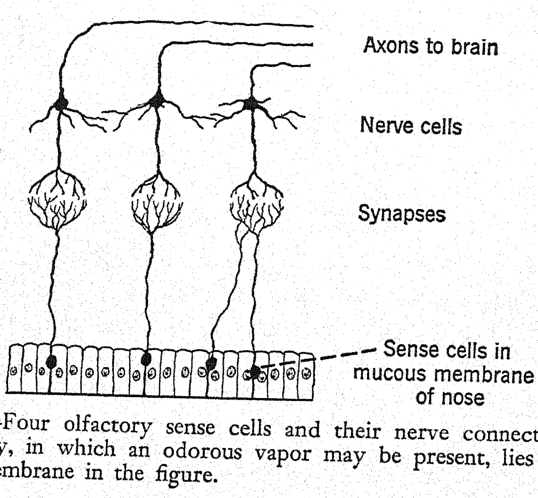

FIG. 97.—Four olfactory sense cells and their nerve connections. The nasal cavity, in which an odorous vapor may be present, lies below the mucous membrane in the figure.

cannot be explored as the skin and tongue have been. The receptor cells are embedded in the mucous membrane lining the nasal cavity and have fine tips which are exposed to the air in the cavity and so to chemical stimulation by odorous substances inhaled in the air.

Since we cannot apply stimuli to the separate receptors, about all that can be done in the way of analysis is to assemble a complete assortment of odors, and become thoroughly acquainted with their similarities and differences. Series can be arranged, grading off from one salient odor through intermediates to another salient odor. Recent work indicates about six salient odors, but whether these are true primaries or not is still uncertain. The following is Henning's classification, or list of the salient odors (*6*):

1. Spicy, found in cloves, cinnamon, etc.
2. Fragrant, found in heliotrope, vanilla, etc.
3. Ethereal, found in orange oil, ether, etc.
4. Resinous, found in turpentine, pine needles, etc.
5. Putrid, found in hydrogen sulphide, etc.
6. Burned, found in tarry substances.

These being the outstanding odors, there are many intermediates. The odor of roasted coffee is intermediate between resinous and burned, that of peppermint between ethereal and spicy.

The lower portion of the interior of the nose is supplied with the cutaneous senses, which are stimulated by many inhaled substances and contribute to what we call the "odor" of those substances. The "smell" of camphor or of menthol is partly cold sensation, and the "pungent odor" of ammonia, acetic acid, chlorine or iodin is partly pain.

The stimulus of the sense of smell is undoubtedly chemical, but the chemical correlations are not yet well worked out. It is an extremely sensitive sense, responding to very small quantities of certain substances diffused in the air. Other substances arouse no olfactory response at all. Many animals, such as the dog, make much more use than we do of this sense in exploring the world; but we probably use it more than we suspect.

THE SENSE OF HEARING

Sound is physically a wave motion or vibration in the air or other conducting medium. In the air, it consists in

a slight back and forth motion of the air particles, a motion usually too slight to be felt by the sense of touch. The ear is much more sensitive, by virtue of its sense cells and accessory apparatus.

The sound-receiving apparatus of the ear. We speak of the outer, middle, and inner ear. The outer ear is a collector, the middle ear a transformer, and the inner ear the sensitive

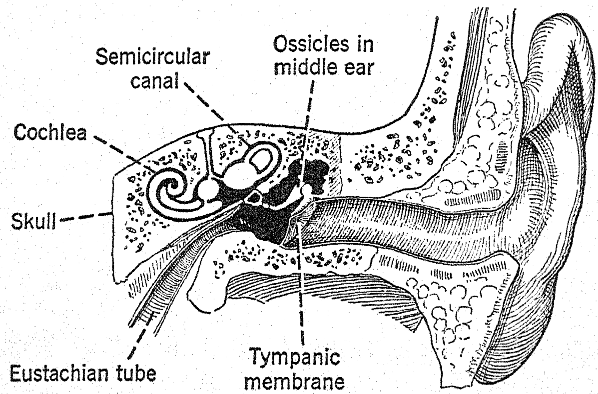

Fig. 98.—The ear, outer, middle, and inner. Sound waves entering the outer ear strike the tympanic membrane (ear drum) and throw it into vibration. The vibration is transmitted by the ossicles to the liquid filling the inner ear and so reaches the cochlea. The middle ear is filled with air which comes in by way of the throat and the Eustachian tube.

receptor. In man, the outer ear has little of the ear-trumpet action so beautifully shown by the donkey, and can be cut off with no noticeable effect upon hearing. Sound waves, entering the ear hole, strike the *tympanic membrane* within and set it into vibration. The membrane communicates its motion to the *ossicles*, an assembly of three little bones in the middle ear, and these concentrate the vibration upon a small opening from the middle to the inner ear. Thus the middle ear mechanism achieves the important result of setting into vibration the saline water that fills the inner ear.

The inner ear is first of all a cavity in one of the skull bones—a very small cavity, but complicated, with a *vestibule* in the middle, and a spiral passage and three *semicircular canals* opening out of the vestibule. The spiral passage,

called the *cochlea* ("snail"), contains the auditory receptors. These are sense cells with delicate hair branches above, and with the fibers of the auditory nerve ramifying below. The sense cells rest on the *basilar membrane*, which is a fibrous ribbon stretched sideways between two shelves of bone and extending the length of the cochlea, widening from one end to the other, and as it widens becoming slacker and more heavily loaded by the overlying cells. These details agree in suggesting that one end of the basilar membrane is

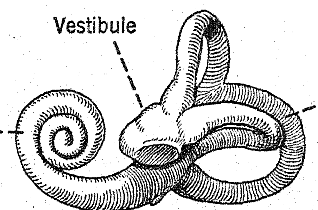

FIG. 99.—The cavity of the inner ear. The receptors are inside this cavity. Notice that the three semicircular canals lie in three planes approximately perpendicular to each other.

tuned to rapid sound vibrations and the remainder to slower and slower vibrations, like the strings of a harp or piano.

Theories of hearing. Helmholtz's "piano theory" or *resonance theory of hearing* accepts this suggestion and assumes that each region of the basilar membrane, being tuned to a certain vibration rate, is thrown into sympathetic vibration whenever the liquid filling the cochlea is vibrating at that rate. (Sympathetic vibration is illustrated by pressing the piano pedal that lifts the dampers from the strings and singing a note into the piano. On ceasing to sing you hear the piano answering with the same note, because the strings tuned to that note have been thrown into vibration by the air waves produced by your singing.) When a tone of a certain vibration rate is transmitted by the middle ear mechanism to the liquid of the inner ear, the corresponding region of the basilar membrane is supposed to be thrown into vibration. When, as usual, more than a single vibration rate is present in the incoming sound, two or more regions of the

basilar membrane are thrown into vibration. Whatever part of the basilar membrane is made to vibrate, the hair cells located on that part are shaken and stimulated; they in turn stimulate the connected nerve ends and start nerve currents toward the brain. Differential tuning of different parts of

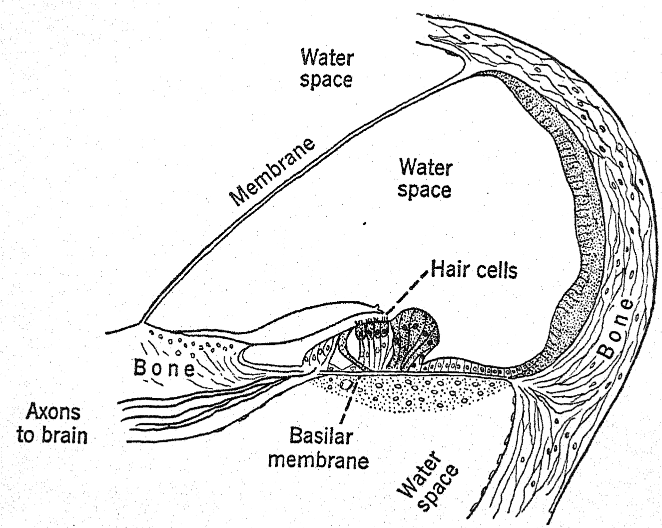

FIG. 100.—Cross-section of the cochlea, showing a single row of the sense cells. There are about 5,000 such rows standing on the basilar membrane. Each of the three "water spaces" is a long slender tube. The sound waves come in from the middle ear and vestibule by the uppermost of the three tubes, pass through the membranes, and are carried back by the lowest tube to a vent leading to the middle ear. They do their work while passing through the basilar membrane.

the basilar membrane would explain the individual's ability to distinguish sounds of different vibration rate, to hear high, low and intermediate tones, and to "hear out" single tones from a chord or single noises from a medley of sound (*5, 10*).

If this theory is correct, an injury to a limited portion of the cochlea should impair hearing, not for all tones alike, but for tones of a certain approximate vibration rate. In human subjects loss of hearing for the very high tones is fairly common. Post-mortem examination of many individuals whose loss of the high notes has been accurately determined shows that the narrow end of the basilar membrane, which

according to the theory is tuned to the high notes, is the part affected (*2*). These results support the piano theory of hearing, which however is not free from difficulties. The *telephone theory* regards the ear as simply a transformer of vibrations from one medium into another—from the liquid contents of the inner ear into the auditory nerve. By tapping the nerve currents and leading through amplifiers, investigators are seeking a decision between these rival theories (*11*).

Auditory sensations and their stimuli. An auditory sensation, the hearing of a sound, is a response of the ear and brain to vibrations striking the ear. Heard sounds are roughly classified into tones and noises, tones being relatively smooth and steady, and noises mixed and irregular. Noise is produced by an unsteady medley of vibrations, tone by a sequence of uniform vibrations.

Heard sounds differ in loudness, in pitch and in timbre. By *pitch* is meant the highness or lowness of a tone. The soprano voice has a high pitch, the bass a low pitch. By *timbre* is meant the characteristic sound of different instruments and other sources of sound. A violin, a cornet and a human voice may all give the same note or pitch with the same loudness, but they can easily be distinguished by their timbre.

Now we must find three ways in which the vibratory stimulus can differ, to account for these three differences in the sounds heard. Air vibrations, if simple, differ in only two independent ways, in amplitude or extent of the back-and-forth swing, and in the frequency or rate of the swing, the number of vibrations per second. Compound vibrations differ also in composition, i.e., in the number and relations of the simple vibrations of which they are composed.

Loudness depends on the amplitude of the vibration; the greater the amplitude the louder the sound. But loudness depends also on frequency of vibration, since (a) for a given amplitude a more rapid vibration delivers more energy per second to the ear, and (b) the ear is more sensitive to me-

dium and fairly high vibration rates than it is to low rates.

Pitch depends on the vibration rate (and to a slight extent on the amplitude of the vibration); the higher the rate, the higher the pitch of the heard sound. Timbre depends on the composition of a complex vibration.

The deepest audible tones have a vibration rate of about 20 per second, and the highest a rate of about 20,000. Outside of these limits, there are plenty of physical sounds, but they arouse no auditory sensation. A giant organ pipe may emit vibrations at the rate of only 16 per second, and shake the whole auditorium, but these vibrations cannot be heard. A tiny whistle gives out 30,000, 50,000 or more vibrations per second, and these can be heard by some animals but not by the human ear. Individuals differ in their upper and lower pitch limits, and the upper limit declines gradually after the age of twenty years.

Though the ear is tuned to respond to this wide range of vibration rates, it is most sensitive to the middle part of the range, from 500 to 5,000 vibrations per second. Weaker vibrations can be heard at these middle rates than toward the extremes of the audible range.

Middle C of the piano, a note within the compass of all voices, though rather low for the soprano and rather high for the bass, has a vibration rate of about 260 per second. Go up an octave and you double the vibration rate; go down an octave and you halve the rate. The whole range of audible tones from 20 to 20,000 vibrations per second amounts to 10 octaves, of which music employs about 8 octaves, finding little aesthetic value in the highest and lowest audible tones. The smallest step on the piano, called the semitone, is $\frac{1}{12}$ of an octave; but this is by no means the smallest pitch difference that can be perceived. Most people can distinguish tones that are 4 vibrations apart, and keen ears can detect a difference of less than one vibration; whereas the semitone, at middle C, is a step of about 16 vibrations. The semitone is simply the smallest step utilized by the European scale, which came down from the Egyptians and Greeks. Ori-

ental music uses different scales, and smaller steps than the semitone.

Combinations of tones—timbre. If two or more notes sound together, a chord or discord is produced. The aesthetic value of the combination depends partly on the relative vibration rates of the component notes, partly on the hearer's being accustomed or not to this particular combination (a wholly unfamiliar combination being distasteful and a perfectly familiar combination being trite and uninteresting), and partly on the total pattern of successive chords in which the given combination occurs.

A chord or discord is a blend, from which you can, to some extent, especially after practice, hear out the component notes. The auditory apparatus is to quite an extent an *analyzer*, making it possible to hear separate sounds out of a combination that simultaneously affects the ear. Thus, to take an obvious but important instance, you can hear what one person says to you through the din of other voices, street noises, etc. One sound does mask another to some extent, especially when both are of about the same pitch, but the degree to which you can hear out the separate sounds is remarkable, when the fact is considered that they are not separate in the air but enter the ear combined into one complex wave motion. According to the piano theory it is the ear itself which breaks up the compound wave into its component waves. If the parts of the basilar membrane are tuned to different vibration rates, then the parts corresponding to the vibration rates of a mixed sound entering the ear will respond separately, and so break up the complex wave into its elements. According to the telephone theory the analysis takes place in the brain.

Even a single note of an instrument produces a combination of different vibration rates. Every sounding body gives off *overtones* along with its fundamental tone. The whole stimulus given off by middle C of the piano is a complex of fundamental and overtones, and the sensation aroused by this complex is a blend. We can, by careful attention and practice, hear out some of the overtones from the blend, but

ordinarily we take the blend as a unit (just as we take the taste of lemonade as a unit), and simply get the characteristic quality of piano notes. Another instrument will give a different combination of overtones, and so a different blend, a different total quality. The timbre of an instrument depends on the particular combination of overtones which it gives out.

Speech sounds. These are perhaps the most important of all sounds for human beings to hear. The great handicap

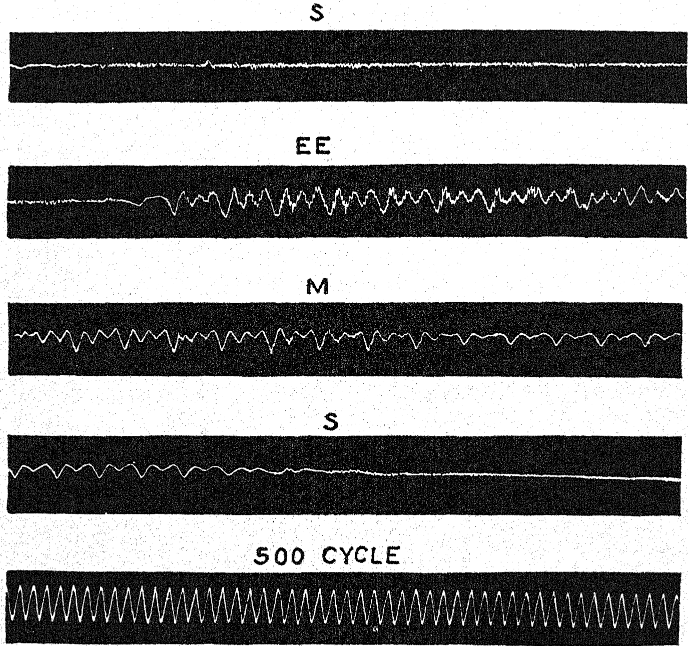

FIG. 101.—(Fletcher, *4*.) An oscillograph record of the sound waves produced in speaking the word, "seems." The unvoiced *s* gives only small, rapid mouth waves, but as the vowel *ee* begins, the vocal cord tone and overtones appear. The bottom line shows the simple waves produced by a tuning fork vibrating 500 times per second.

of the deaf child, which shows in his IQ, is probably his inability to hear what other people say. If we had time for a thorough study here, we should begin with the production of speech sounds by the vocal cords and by the mouth. One important fact is that the vocal cords supply the voice element in speech sounds—an element that is absent in whis-

pering and in the "unvoiced" consonants such as k, p, t, f, and s. The vocal cords emit overtones along with the fundamental tone that is being spoken or sung. But the vocal cords by themselves produce no vowels or consonants. These are due to the various positions of the mouth, tongue and lips. Any one of these positions forms a resonance chamber that strengthens certain of the vocal cord over-

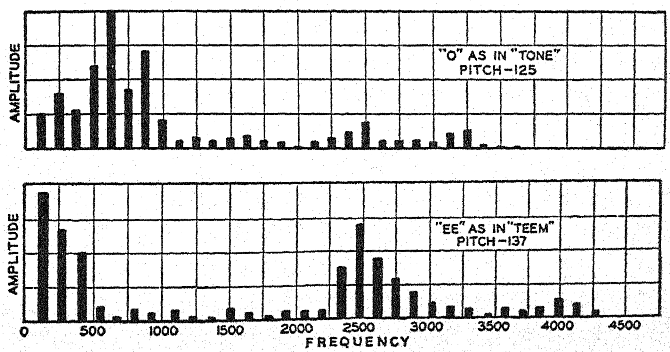

FIG. 102.—(Fletcher, *4.*) An analysis, made by an electric analyzer, of the vibrations composing the sound of the vowels *o* and *ee*. The location of the bars along the base line indicates the vibration rate of each component, while the height of the bars indicates the relative strength of the several components.

tones, and by so doing gives the vowel or consonantal quality.

Compare the mouth positions for saying *o* as in "tone" and *ee* as in "teem." The *o* position reinforces the vocal cord overtones in the region of 500 per second, the *ee* position reinforces those in the region of 2,500 per second. Notice also the position for saying *s*: the tongue is brought up to the base of the upper teeth, leaving a narrow passage for the air, which whistles through giving a very rapid vibration (about 7,500 per second), which can readily be heard in whispering the sound *s*. If you sound *z*, the corresponding voiced consonant, you can hear both the vocal cord tone and the hissing at the front of the mouth. You can feel them both, as well, in pronouncing this letter. Each speech sound is a different combination of tones. The development of

telephone, phonograph and radio engineering has made it possible to obtain beautiful records and analyses of speech sounds.

In hearing speech, we do not hear out the component tones to any great extent, but recognize the total complex as a familiar blend. Even a whole syllable, composed of several successive speech sounds, is heard as a total pattern.

From the high pitch of many of the overtones that enable us to distinguish one vowel or consonant from another, we see how useful it is to have ears very sensitive to what might otherwise seem absurdly high vibration rates, from 2,000 to 10,000 per second, away above the range of the human voice, i.e., of its fundamental tones. These high overtones are weak in comparison with the vocal cord fundamental, and, as the sensitiveness of the ear to high tones decreases with age, one finds it more difficult to hear what people are saying, though one can still hear the rumble of their voices.

The elementary auditory sensations. Simple tones, free from overtones and noises, can be arranged in a continuous pitch series, from the lowest to the highest audible tones, with no breaks, "corners" or "salient sensations" such as we have found in the other senses. The notion of a few primary sensations, which was useful in understanding the cutaneous senses, sight, taste and possibly smell, has no value in the case of hearing. Every tone, provided it is a single tone, is as primary as any other. This continuous scale of auditory responses makes the ear a much better registering instrument for sound than the eye is for light. The ear registers the component vibrations of a chord much more adequately than the eye can do for a mixture of light rays. In compensation, the eye is far superior to the ear in registering space relations.

Localization of sounds. Such ability as we possess to perceive the direction of a source of sound arises primarily from the fact of *binaural hearing*. A sound from the right side strikes the right ear with more force than the left, and strikes it a small fraction of a second sooner, and thus binaural hearing furnishes signs of direction, so far as right and left are

concerned. In an open field, free from echoes, one can face very accurately toward an unseen source of sound. The external ears look like shields that would furnish a front-back distinction, but experiment shows that the human individual has very little ability to tell whether a sound is coming from in front or behind—unless, to be sure, he turns his head and so converts the front-back dimension into a right-left dimension. In familiar surroundings and with familiar sounds, we have learned to use various other indicators of the direction and even the distance of the sounding body. If we recognize the sound, its loudness indicates how far off its source must be. The blind, more than the seeing, utilize echo and resonance for indicating the location of walls that reflect sound. There are many such indirect and learned indications of the location of the source of a sound. But binaural hearing remains the fundamental indicator.

Recalling Stratton's experiment (p. 490) with the inverted field of view, we may query what would be the effect on sound localization of interchanging the sounds that enter the two ears. The experiment has been tried (*12*) by fitting a tube into each ear hole and carrying it over the head to end in a receiving horn close to the other ear. Thus each ear got the stimulus that would normally enter the other ear. The subject wore this instrument for an hour or two a day for two weeks, and then all day for three days. The first effect was a complete right-left reversal in the localization of sounds, with much tendency to front-back reversal as well. The creaking of a door would be heard from the right rear but a person would be seen entering the door at the left front. Finding a ticking clock, with eyes closed, was a baffling task, for the more one went "toward" it the more it receded. With the eyes closed, this reversed localization persisted throughout the experiment with little indication that it would yield to training. But when the eyes were open they tended to dominate the ears. Even from the start of the experiment, when an object was *seen* making a noise, as a horse walking in the street, the noise sometimes seemed to come from the seen object; the visual signs of location prevailed over the

auditory. The visual cue at first had to be very clear in order to overbear the auditory, but as the experiment progressed vision dominated more and more, and the visual localization remained even after an object had gone out of sight, so that the subject could be in a busy street and hear all the sounds as coming from their objectively true sources. When the

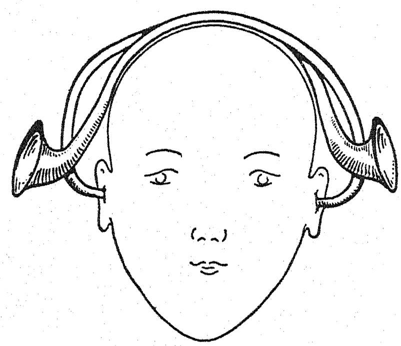

FIG. 103.—Diagram of Young's pseudophone (*12*). Each ear trumpet is continued by a tube that runs over the head and is plugged into the opposite ear.

instrument was finally removed, the switch back to normal localization was immediate and complete.

THE SENSE OF HEAD POSITION AND MOVEMENT

It is a surprising fact that some parts of the inner ear are not connected with hearing at all. In fact, if we trace the ear back in the animal series, we find that its first use was to respond not to vibrations, but to movements and positions of the head. The cochlea is a recent addition to the ear, and so also are the middle and outer ear. The vestibule and the semicircular canals are the old parts, and they are fundamentally more important than hearing, because, being stimulated by positions and movements of the head, they provide the sensory data for the maintenance of posture, orientation with respect to gravity, equilibrium, and steadiness of movement. They enable the fish to keep right side up in the water, the bird in the air, the frog to right himself instantly if placed

on his back, and the cat to land on her feet when falling from a tree.

There are receptors in the vestibule and semicircular canals, consisting of hair cells, somewhat similar to those in the cochlea. In the vestibule, the hair-tips of the sense cells are matted together, and in the mat are embedded little particles of stone, the *otoliths.* When the head is inclined in any direction, these heavy particles sag and bend the hairs, so stimulating them; and the same result occurs, by inertia of

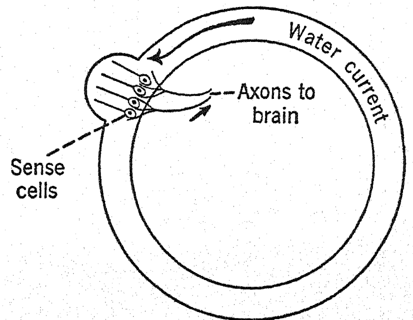

FIG. 104.—How the sense cells in a semicircular canal are stimulated by a water current. This current is an inertia back flow produced by a turning of the head in the reverse direction.

the heavy particles, in any sudden starting or stopping of the body's motion. Around the base of the hair cells twine the fine terminations of sensory nerve fibers, which are excited by the activity of the sense cells, and pass the activity on to the brain.

Each semicircular canal has a bunch of sense cells, with long hairs sticking up into the water like reeds growing in a stream. Now, though the canals are called "semicircular," each is considerably more than a semicircle and, opening at each end into the vestibule, amounts to a complete circle. Rotating the head produces, by inertia of the water, a back flow in one or more of the canals, which bends the hairs and stimulates them. As the semicircular canals lie in three planes at right angles to each other, they provide a complete analyzer for head rotations in any direction. Meanwhile, the otolith receptors, which are also arranged in different planes,

analyze the positions and rectilinear movements of the head. Thus the inner ear as a whole—quite apart from the cochlea—provides a complete analyzer for head positions and movements.

This sense is strongly stimulated by whirling, swinging, sudden starting or stopping (as in an elevator), turning somersaults, etc. The resulting sensations have a dizzy quality, but it is not certain that all dizzy sensation arises from the inner ear. It is certain, from physiological experiments involving destruction of part or all of the inner ear or its nerves, that postures, righting movements and steadiness of progression depend on this organ, as well as on the muscle sense.

Perception of slight rotations depends on the canals, and is lost when both inner ears are spoiled by disease. If a person is placed, blindfolded, in a chair that can be rotated without sound or jar, he can easily tell when you start to turn him, and in which direction. If you keep on turning him at a constant speed, he soon ceases to sense the movement, and if you then stop him, he believes you are starting to turn him in the opposite direction. He perceives the beginning of the rotation because this causes a back flow in the canals; he soon ceases to sense the uniform rotation because friction in the slender canals stops the back flow; and he mistakes the arrest of rotation for the start of an opposite rotation because the water in the canals continues flowing by inertia for a short time after the rotation ceases.

PERCEPTION OF OBJECTS BY THE NON-VISUAL SENSES

Though sight is the most objective of the senses, all of them contribute to our knowledge of facts. The interoceptors make the individual aware of his own states of hunger and thirst. The skin senses yield much knowledge of objects, as to roughness or smoothness, moistness or dryness, warmth or coldness, hardness or softness, size and shape (*8*). The muscle sense reveals the weight and firmness of objects.

Taste tells what kind of substance has been taken into the mouth, and smell indicates the presence of objects having a characteristic odor. The semicircular canals reveal the objective fact of rotation of the individual's head and body by some external force.

As to the auditory sense, the same question might be discussed as was raised in the case of sight. Do we hear sounds, or do we hear objects? The answer with regard to noises would certainly be that we usually hear them as the sounds produced by objects. We speak of hearing the wind or the waves, an airplane or a bee, a man sawing or a horse trotting. When we hear a noise that we cannot identify, we are uneasy, for our tendency in hearing as in seeing is to get back of the stimulus to the environmental fact.

In listening to music, indeed, we may be quite content to take the tones as they come without asking by what particular instrument of the orchestra they have been emitted. What is specially characteristic of the hearing of music is the fact that we hear the tune rather than the separate notes.

In listening to a person talk, there are four things we are hearing. We hear the sounds that reach our ears, the stimuli. We hear the person, the object emitting the sound, as in another case we hear an automobile. We hear words and sentences which are sound patterns. It may seem forced to say that we hear the speaker's meaning, but at any rate that is what we are trying to get. To penetrate behind the words to the meaning shows the same objective tendency in the listener as we have seen in numerous instances of going behind stimuli to their source in the environment.

Emphasizing as much as we have the use of the senses for perceiving objective facts, and the observer's strong tendency to go behind the sign to its meaning, we may leave a false impression that it is never advantageous to observe the bare stimuli. Sometimes the sign is ambiguous and the part of prudence is to avoid plunging instantly to the suggested meaning. On shipboard you see a vague something along the horizon and exclaim, "I see land"; but a sailor assures you it is only a cloud. You "hear a burglar" in the middle of

the night, when it is only some creaking thing about the house. It is well to be able at will to strip off the meaning and get down to the stimuli. This ability is especially necessary for anyone who wishes, like the painter, to manipulate the stimuli, or, like the piano tuner or the teacher of pronunciation, to improve the sources of stimuli.

Summary of the chapter. Every sense has its interesting peculiarities. The skin seems to give four elementary sensations: warmth, cold, touch and pain; and the sense of taste four more: sweet, sour, bitter and salt. But there are many blends, including blends of touch and kinesthetic sensations, and blends of taste and smell. Though certain outstanding odors can be detected in the multiplicity of odors, no real analysis into elements or primaries has been accomplished. Hearing is a remarkably analytic sense, giving tones of different pitch corresponding nicely to the vibration rates of the stimulus, and providing the data for hearing out a single tone or noise from a medley of sounds. Hearing is superior to sight in this respect but it is quite inferior as a space sense. It does give a good right-left distinction in the localization of sounds, dependent on the possession of two ears. Overtones are important in the various sounds of speech and of musical instruments.

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Chapter XVI

Thinking

AS EACH new topic is introduced, as each phase of the individual's activity is considered, whether learning, motivation or observation, the great practical importance of the new topic is easily seen. It would be difficult to decide which phase of activity is the most important, and perhaps none is more important than the rest because they are all interlocking operations. Learning depends on observation and on motivation. Motives are built up by observation, learned and retained. Observation utilizes what has already been learned, and incisive observation depends on some motivating need or interest. These phases of activity are singled out for separate study but in reality they all work together.

Now we reach another main phase of activity which we may call *thinking*. A good argument could be put up for the superlative importance of this phase. The welfare and progress of society depend on the scientists, inventors, artists, foreseeing statesmen and others who do more than repeat what they have learned—who by clear thinking and bold imagining increase our knowledge of the world, both physical and social, and blaze the way toward better living. Democracy, especially, is much concerned to foster thinking ability throughout the population and to have inventiveness directed to social as well as material problems. Not only the social group, the individual also in his own interests needs some power of thought if he would free himself from blind impulse and the ruts of habit and discover or invent for himself a more adequate mode of life.

The broad topic of thinking can be apportioned more or less arbitrarily into two chapters, one devoted mostly to reasoning, the other to imagination. Thinking has two main goals, discovery and invention. It seeks the truth and it tries to devise something better.

Reasoning may be described as *mental exploration*, imagining as *mental manipulation*. What we mean by calling them mental is the same as in the simpler cases mentioned in an early chapter (p. 33). It is possible for human beings to explore and manipulate without dealing directly with the present environment. "Ideas" can be explored and manipulated, and often with excellent results in subsequent dealings with the real environment. Such activity, not concerned with the present environment either by way of observing it or by way of manipulating it, is called ideational, and the two chapters now before us might be combined under the head of *ideation*.

Simple forms of thinking. "Let–me–think," we say under certain conditions. "What was that man's name?" If the name came up instantly we should not need to think. Thinking is one way of overcoming an obstacle. The obstacle to recall may be circumvented by thinking of the occasion on which we saw the person in question. Here we are exploring past experience or our stock of memory traces. More in the direction of manipulation is such a case as this: "Let me think; how can this furniture be arranged to improve the appearance of the room?" One imagines the pieces in various positions and tries to judge the aesthetic effects. How is this possible? One may recall specific experiences or particular arrangements of furniture that have been attractive or otherwise, and it is safe to assume that past experience is utilized in a more general way even when something quite new and original is imagined. Without any background in past experience one would be helpless before such a problem, or one would have to manipulate in reality, trying out each arrangement that suggested itself with no economy of effort due to thinking.

Our definitions may get us into a snarl. Certainly we may

combine thinking, observing and actual manipulating of objects in one single activity. To deal with the present reality we need not cease thinking, and to think we need not close our eyes or fold our arms—though sometimes that is just what we do. Probably ideational thinking arose out of what we may call *perceptual thinking* which consists in dealing with present objects (e.g., chessmen) according to the meanings they have acquired in our past experience. If the chimpanzee in the famous jointed stick experiment (p. 297) was actually engaged at a certain moment in trying to make a longer stick, he was doing some perceptual thinking, and he was utilizing his past experience with sticks and distances. How and when ideational thinking originated we do not know. It may have grown out of the anticipation visible in the animal experiments on delayed response and conditioned response (pp. 305, 310). Full-fledged ideational thinking—thinking to good effect without having the objects present—is perhaps a purely human achievement. Certainly it is an important achievement, but it differs more in degree than in kind from perceptual thinking, since both are utilizing meanings derived from past experience.

Another simple example of thinking brings out some additional points. Suppose you need the hammer, and go to the place where it is kept, only to find it gone. Now if you simply proceed to look here and there, ransacking the house without any plan, that would be motor exploration. But if, finding this trial and error procedure to be hopeless, you sit down and think, "Where can that hammer be? Probably where I used it last!" you may recall using it in a certain place, go and find it there. You have substituted mental for motor exploration, and saved time and effort.

Thinking often economizes time and effort. Another point that comes out of this example, in contrast with the case of trying to think of a name, is that here what is recalled serves as a guide to action. Usually, in thinking, recall provides data for further use in solving a problem. What was recalled in this case amounted to a general principle (often put in form of a maxim, "Think where you had it

last"), and this principle was recalled and applied to the present problem.

Transfer, foresight and hindsight, in thinking. The principle applied to a new problem may have been picked up in the form of a rule or maxim, from people wiser than ourselves. Or it may have been derived from our own experience. When mastery of one problem yields principles that are later applied in another problem we have the kind of "transfer" that experiment shows to be most effective (p. 362). The human subject may discern such principles himself, without the aid of a teacher, as is found in experiments in learning mechanical puzzles (p. 315). The subject on his first trial can usually not see into the principle of the thing. He sees certain possible leads but cannot follow them through by mere inspection of the puzzle. He must try the leads, but he can be on the watch to see how they come out. The best he can hope, on his first trial of a new puzzle, is to derive from it some useful "hindsight." It may be that his hindsight consists merely in noticing where he succeeded, but even this is useful on the next trial. What was hindsight on the first trial becomes foresight for the next trial; he knows in advance where to work. The more clean-cut his observation on the first trial, even to the point of being formulated in words, the surer it is to be recalled on the next trial and to serve as a useful guide. What is true in this experiment holds good in many life situations. You attack a novel problem somewhat blindly, but you may derive from it, when solved, some hindsight that can later be used as foresight in a similar problem. Often, however, you are so relieved at escaping from a difficult situation that you forget it as soon as possible, instead of asking yourself what you can learn from it that may serve as a guide in some future problem.

Even the most observant person is not able to apply his principles to every new problem. Two puzzles may be built on the same principle but camouflaged so as to look altogether different. That is, a present situation may not suggest, or recall, the principles that would apply; it may

suggest other principles that do not apply and put you on the wrong track. Even if the correct principle is recalled, it may need to be adapted to the peculiarities of the present situation. It cannot be applied mechanically. All in all, learning by experience and using the teachings of past experience are not easy, sure-fire procedures.

REASONING

Though no sharp line can be drawn between the simpler and the more complicated forms of thinking, we will use the term, *reasoning*, for thinking that involves more than immediate use of a fact or principle that has been recalled. Our example of trying to think of a person's name would not be called reasoning because, though there may have been a long hunt for the name, once it was recalled the thought process was ended. Finding the hammer by aid of thought would be a process of reasoning if it proceeded as follows: "Where is that hammer? Remember the rule to look for a lost object where you last used it. I last used it in the attic. Therefore, it must be in the attic." That "therefore" indicates that a *conclusion* was drawn from the two recalled items, the rule and the memory of using the hammer.

In reasoning, items furnished by recall, present observation, or both, are *combined* and examined to see what conclusion can be drawn from the combination. (An "item" here may be any fact or principle, large or small, broad or narrow–anything that can be observed or recalled.) The items may be obtained from another person in conversation or reading. The crucial step in reasoning is the drawing of the conclusion. *To draw a conclusion is to see the implications of a combination of items*–of facts, principles, ideas, statements, whatever the items may be. The reasoner has to hold these items together while examining them to see what they mean or imply when combined. If he is doing all the work himself, he has to assemble the items by recall from past experience or by fresh observation. And when he has drawn his conclusion he usually wants to test it out,

to verify it in some way. The whole process, then, contains several part processes:

1. Gathering the data
2. Combining the data
3. Seeing the implications of the combined data
4. Testing the conclusion so reached

Though it may seem logical to expect these part processes to occur in 1, 2, 3, 4 order, as a series of "steps in reasoning," the actual procedure is often much jumbled, as we shall see directly.

Gathering the data. Really something precedes the search for data. There is some question to be answered, some sort of *problem* to be solved. Typically, the individual while set for a goal encounters an obstruction, and his reasoning amounts to mental exploration directed to finding a way around the obstruction. Or, we may say, he is confronted by a problematic situation and seeks to clarify it by thinking. So he is stimulated to observe something in the situation, or to recall something from his stock of facts and principles, that promises to help. As soon as he gets a lead he eagerly follows it up to a conclusion, if possible, but the first lead is likely to prove futile, and he has to try again. So the process does not run off smoothly as a series of steps.

The reader familiar with geometry, which is distinctly a reasoning science, will readily verify this description. It is true that each demonstration is set down in the book in excellent order, proceeding straight from the given assumptions to the final conclusion; but such a demonstration does not by any means picture the mental process of reasoning out a proposition. Solving an "original" is anything but a straightforward process. One examines what is given, turns to see what has to be proved. One tries to work forward from what is given, backward from what is to be proved. Various leads are found and followed forward or backward, till finally some forward lead connects with some backward lead and so a complete line of proof is discovered (*5*).

(Here is an original for the reader to try, if his geometry

has not succumbed to "atrophy from disuse": Prove that a circle circumscribed about a square has twice the area of a circle inscribed in the same square.)

Reasoning and trial and error. Some psychologists like to speak of reasoning as a trial and error process at the ideational level, while other psychologists insist that reasoning is the very antithesis of trial and error. If we review our analysis of trial and error (p. 294) we find that this type of animal (and human) behavior takes its start in a set for a certain goal, with inability to see a clear path to the goal; that it proceeds by exploring the situation, finding and trying leads, backing off when blocked and trying another lead and finally finding a good lead and reaching the goal. The leads are found by direct observation and tried by overt movements dealing with the actual situation. In typical trial and error, then, we can distinguish two characteristics: the active sensorimotor performance, dealing directly with the environment; and the try-this-try-that pattern of the whole enterprise. Reasoning shows this last characteristic. It shows the general pattern of trial and error. It is the very antithesis of trial and error in its method of attack, since it thinks the leads through instead of trying them out at once in a motor way, and also since it gets some of its leads from memory instead of from direct observation. In both cases there is a goal set that holds the activity within bounds, keeps it from straying far from the goal, and limits the exploration to leads that have some promise.

Why should the reasoner flounder about as much as he does? Some floundering is unavoidable for the same cause as in trial and error: inspection does not reveal the path to the goal, and leads have to be explored. The first lead that is spotted is likely to prove a blind alley and other leads must be tried. But there is often a surplus of floundering, due to two causes that could be avoided. One cause lies in *fixed assumptions*. The reasoner is apt to get a false idea of the nature of the problem and to stick to this assumption through thick and thin. He has got into a rut and sometimes can only escape by dropping the problem for the time being.

When fresh he has a better chance of seeing the problem with an open mind. Several investigators, using puzzles and similar problems in experiments on reasoning, have noticed this difficulty of fixed ideas (*1, 10, 13*).

Another cause of superfluous floundering, almost the reverse of the first, is the *incomplete testing* of leads. The reasoner does not always follow a lead far enough to make sure whether it is good or bad. Consequently he comes back again and again to the same old lead and gives it another half-hearted try. What advice can we give him? If we emphasize thoroughness—"one thing at a time and that done well"—he will waste time in doggedly following up false leads. If we preach the gospel of openmindedness, he will flutter around like a butterfly. We shall have to hold up the ideal of the golden mean between these two extremes.

Combining the data. The data must be brought together into a compact assembly so that their interrelationships can be seen. When the mass of data to be handled is large it may exceed the individual's "span of apprehension" (in a somewhat extended sense of that term, p. 458). A child, especially, is unable to grasp a large body of facts (*3*). As he grows older his span increases.

It is not entirely a question of holding together as much as possible. The principle of selectivity comes in as well. Some of the data are probably useless, irrelevant. "How many square yards of green carpet will be required to cover one end of a box that is 3 feet high, 3 feet wide, and 8 feet long, built of one-inch pine boards?" Such questions are likely to confuse a child and would ordinarily be condemned as trick questions. Yet they are not unlike the data that are met in life problems. Of course the reasoner cannot always tell by inspection which data, if any, are irrelevant. His only recourse may be to try the effect of leaving some of the data aside for the moment and seeing what can be done with the remainder.

Seeing the implications of the combined data. This is the crucial point in the whole process. If the reasoner has got together the right data, the answer to his question is there,

but can he read the answer from the combination? He may still lack a unifying idea to give the data some sense, some implication bearing on the question at issue. The unifying idea must also be an operating idea, furnishing a plan for working out the data.

Let us take an example. My friend has driven up the highway, making an average of 40 miles per hour. One hour later I start out to overtake him, making an average of 50 miles per hour. How long will it take me to overtake my friend?

I assemble the data: "one hour start, 40 miles per hour for him, 50 miles for me." These elements of the problem do not instantly fall into a usable pattern. Some unifying, operating idea is needed. One such idea is given by the question, "How much distance am I going to *gain* per hour?" I make 50, he makes 40; so I gain 10 miles per hour. How much total distance have I got to gain? He has been out an hour and is now 40 miles ahead. I have to gain 40 miles, gaining 10 miles per hour. It will take me 4 hours, and I shall be 200 miles from here when I overtake him.

If this conclusion does not seem probable to me, I can test it by some other method of computation, provided I can find another operating idea. I can use algebra, letting $x =$ the number of hours I must travel, and seeking some unifying idea that will give me an equation. If this method checks with the other, I am forced to admit that the conclusion, however improbable it may seem, is implied in the data. I can still check the answer empirically. If I overtake my friend in 3½ hours, my first impression is that I have reasoned incorrectly. But I ask him if he has kept up his usual 40-miles-per-hour average and he tells me he took half an hour out for lunch. So I see that my conclusion was truly implied by the data I had to work with, but that these data did not happen to correspond exactly with the facts.

In seeing the implications of certain data you do not go behind the data. If you doubt the data, check them if possible, or else remember that your conclusion also is subject to doubt; but while trying to discern the implications of cer-

tain data, hold yourself rigidly to those data. The arithmetical problem shows clearly what is meant by the implications of the data. With one car going 40 miles an hour and another car coming up behind at 50 miles per hour, the implication is a gain of 10 miles per hour.

Testing the conclusion. Two methods of testing a conclusion were shown in the previous example: (1) seeing the implications of the data from a fresh angle, and (2) subjecting the conclusion to the test of empirical fact. Sometimes only one of these checks is practicable. There may be no second way of viewing the data, or there may be no way of making a factual test before adopting a course of action. At a fork in the roads, literally or figuratively, we must decide which road to take and gamble on our decision. We have to depend on straight thinking.

In one important class of cases, straight thinking is imperative even though a factual check is to be made.

Some hypothesis is to be tested by experiment. The implications of the hypothesis are examined with the purpose of finding a logical conclusion that can be shown to be true or false in fact. The hypothesis is combined in thought with existing knowledge, and implications are found which can be tested experimentally. The implications show how to set up an experiment to check the hypothesis. The data to be combined are more extensive and often less definite than in an arithmetical problem.

For example, the suggested hypothesis is that "seeing distance, the third dimension, is a learned response." How shall it be brought to a factual test? Dwelling a moment on the statement we are reminded of several items of relevant knowledge: the child cannot use his eyes before birth and therefore (implication) cannot learn before birth to see distance. First conclusion: we should test the child as soon after birth as possible for ability to see distance. How shall we test the baby? This question sends us back for more data. We recall the signs of distance: linear perspective, aerial perspective, covering of a farther by a nearer object; but the meaning of these signs, we think at once, must be

learned by experience. We remember also the binocular signs of distance and think there is more chance that these do not have to be learned. Then we recall the fact that the binocular signs are most powerful when the object is rather close to the subject. The implication is that the baby might be able to distinguish an object a foot away and the same object two or three feet away. But how could we test him, how could we get him to respond? Again we are sent back for more data. We think of the conditioned response method as possibly useful for our purpose. And so on till we have an experiment definitely planned. The importance of straight thinking in this sort of problem is obvious, for unless we see the true implications of the hypothesis our experiment will not afford a valid test, and our science will be encumbered with one more false or dubious finding.

This case illustrates once more the several parts of the reasoning process: the question, problem or goal set which keeps the whole activity within bounds; the search for relevant data; the combining of the data in various promising ways; the seeing of the implications of the combined data; and the testing of the conclusion. Though the thinking is "straight" at the crucial moments, the whole process is anything but a straightforward movement from the starting point to the goal. Leads are found and rejected. Partial or tentative conclusions send the thinker back for more data. The experiment on being first tried may reveal some weakness that makes still more thinking necessary.

Motivation of reasoning. It "goes against the grain" to keep resolutely at a task of reasoning, instead of resorting to motor trial and error. We are impulsive creatures and prefer to be doing something that gets immediate results. In reasoning we encounter obstacles that cannot be pushed aside by the natural reaction of putting in greater muscular effort. We become angry or at least impatient and get into an emotional state unfavorable to holding data together and examining their implications. Yet reasoning does often occur and the motive differs in different classes of cases.

1. Solution of a practical problem. Muscular effort will not overcome every obstacle, and motor exploration is very wasteful of time. A decision has to be made, as in the typical case of the forked road. We are motivated to observe the situation carefully and to recall previous experiences or previously learned facts and principles. Thus we assemble the necessary data, together probably with much irrelevant material, and attempt to draw a rational conclusion.

2. Rationalization or self-justification. While in the preceding case reasoning showed what to do, here it is called upon to justify what has been done. The question is, what reason to assign for our act; we feel the need of meeting criticism, either from other people or from ourselves. The real motive for the act may be unknown to ourselves, as it often is unless we have made a careful study of motives; or, if known, it may not be such as we care to confess. We require a *reasonable* motive, some acceptable general principle that explains our action; and we usually succeed in finding one.

3. Explanation. This form of reasoning, like the preceding, takes its start with something that raises the question, "Why?" Only, our interest in the question is objective rather than subjective. It is not our own actions that call for explanation, but some fact of nature or of human behavior. To explain a phenomenon is to find some general principle from which it can be deduced, and such explanation is very agreeable, since it rids us of uncertainty and sometimes of fear, and gives a sense of power and mastery.

4. Application. While the reasoning processes thus far discussed have taken their start with the particular case and hunted for a general principle to fit the case, reasoning may also take its start at the other end. It may start from the general principle and seek for particular cases belonging under it. But what can be the motive for this sort of reasoning? What is there about a general proposition to stimulate exploration?

The motive may be that of seeing the application of the principle. Somebody whose authority you fully accept

enunciates a principle, and you wish to see how it applies to particular cases; you may have hopes of putting it to practical use, or you may simply wish to clarify its meaning. You search your memory for concrete instances where the accepted principle should apply. If the general proposition is that birds and mammals are the only warm-blooded animals, then fish, frogs and lizards are cold-blooded; also spiders, insects, lobsters and worms; these implications give you a more realistic understanding of the general proposition.

Under the head of application belongs *prediction*. The general principle, applied to a particular situation, enables you to predict the outcome of the situation. Thus the astronomer successfully predicts eclipses, the physician the course of a fever and the results to be expected from a certain treatment, and the engineer the strength of his bridge or the current to be produced by his dynamo. Prediction is a step toward control, so that there is plenty of motivation for this type of reasoning.

5. *Doubt.* A general proposition may stimulate reasoning because you doubt it and wish to find cases where it breaks down. Perhaps somebody makes the general statement whose authority you do not accept, or says it in an assertive way that makes you want to take him down a peg. Perhaps you are in the heat of an argument with him, so that every assertion he makes is a challenge. You search your memory for instances belonging under the doubted general statement, in the hope of finding one that is contrary to fact. If he asserts that all differences in intelligence are due to heredity, you are stimulated to recall the identical twins reared in quite different environments, who differed considerably in IQ in spite of their equal heredity. But if his assertion is that all differences in intelligence are due to environment, what you recall is the identical twins brought up in moderately different homes, who differed much less than the children of a community in general. In either case memory supplies you an exception with which to challenge the offensive generalization of your opponent.

6. Verification. This doubting type of reasoning has much more serious uses; for this is the method by which a *hypothesis* is tested in science. A hypothesis is a general proposition put forward as a guess, subject to verification. How shall its truth or falsity be demonstrated? By deducing its consequences, and checking them against observed facts.

An example from the history of science is afforded by Harvey's discovery of the circulation of the blood, which was at first only a hypothesis, and a much-doubted one at that. If the blood is really driven by the heart through the arteries, returning to the heart by way of the veins, then the flow of blood in any particular artery must be away from the heart, and in any particular vein toward the heart. This implication was readily verified. Further, there should be little tubes leading from the smallest arteries over into the smallest veins, and this implication also was later verified, when the invention of the microscope made observation of the capillaries possible. In time all the implications of the hypothesis were verified, and the circulation of the blood became an accepted law.

Most hypotheses are not so fortunate as this one; most of them die by the wayside, after a shorter or longer career. Born of a few facts, they venture forth like knights into the world with a challenge to all comers, and hold their own for a time, only to be slain at last by some unexpected fact that their challenge stirs up. Even when destined to die, hypotheses are useful to science as motives to observation. The psychological process of scientific discovery is about as follows. You start with some observed facts that seem queer to you, and try to find some accepted law that explains them. If you find no such law in existence, you are driven to invent a new law, or hypothesis, that fits all the facts known to you. Now, if you have the scientific spirit, you put a question mark after your beautiful hypothesis, and proceed to check it up against new facts. You are guided toward the discovery of pertinent new facts by reasoning about your hypothesis and deducing its consequences; you see that, *if* the hypothesis is true, such and such facts must be true.

Next you go out and observe whether the predicted facts are to be found, and if they are found your hypothesis is verified to that extent, though it may be upset later. If contrary facts are found, the hypothesis is false, and you have to begin all over again.

The would-be natural scientist may fail at any one of several points. First, he may see no question that calls for investigation. Everything seems settled, and he concludes that science is complete, with nothing left for him to discover. Second, seeing something that still requires explanation, he may lack fertility in guessing. Helmholtz, an extremely fertile inventor of high-grade hypotheses, describes how he went about it. He would load up in the morning with all the knowledge he could assemble on the given question, and go out in the afternoon for a leisurely ramble; when, without any further effort on his part, the various facts would combine and suggest new explanations. Third, our would-be scientific investigator may lack the clear, steady vision to see the implications of his hypothesis; and, fourth, he may lack the enterprise to go out and look for the facts that his hypothesis tells him should be found.

RELATIONAL THINKING

What we are now to consider is not another form of thinking; rather, it is the seeing of implications and drawing of conclusions, viewed from a different angle. When implications are analyzed they are found to amount to relations. The gain of the rear automobile on the one ahead is a relation between their two speeds. Numerical, spatial and temporal relations are especially useful in solving certain kinds of problems, and many other relations are used in thinking. In arranging the seating of a party at the dinner table, the hostess considers the relations of congeniality and the opposite.

Psychology is not the only science that studies reasoning; *logic* was well developed long before psychology began to examine the concrete processes by which human beings

think, the growth of reasoning ability in the child, the conditions that make reasoning easy or difficult, and other such obviously psychological problems. No sharp line can be drawn between the interests of logicians and psychologists, but we may say that logic deals especially with the question whether a conclusion is logically valid, whether, that is, it is implied by the data. Logic examines implications, and it does so by analyzing out the relations involved. The psychology of reasoning can be better understood if some attention is paid to these relations which the reasoner uses in drawing his conclusion.

Indirect comparison. Many forms of reasoning can be brought under this head. Some rudimentary cases clearly belong there. You wish to compare the girths of an oak and a pine tree. You find you can reach around the oak, but not around the pine. Comparing the two girths with your own reach, you see indirectly which tree is larger.

If Mary and Jane are standing side by side, you can compare their heights directly. But if they are never present at the same time, you stand Mary against the wall when you have a chance and mark her height on the wall, and later do the same with Jane. Comparing the two marks you know which girl is taller.

"Have we set the table for the right number of people?" "Wait till they all come to the table and we can tell." "Oh! but we can tell now by counting. How many are there to be seated? One, two, three . . . fifteen in all. Now count the places at the table—only fourteen. We must make room for one more."

These elementary examples illustrate the fundamental use of counting and measuring. Whenever we wish to *use* a number or measure, it is to compare it with another number or measure. The numbers or measures are brought together and compared, and the objects counted or measured are thus compared indirectly. The relations involved are those of being equal, greater or less, and the implications are such as are expressed by saying that "things equal to the same thing

are equal to each other." These relations are extremely usable tools in reasoning on certain problems.

Other relations of likeness and difference provide similar tools. Two freshmen in college on getting acquainted and comparing notes find that both their fathers are alumni of this same college. "What class was your father in?" "In the class of 1910. And yours?" "Why, he was in 1910, too. Our fathers were in the same class; they must know each other!" Here two separate facts, one contributed by one person and the other by another person, are brought together and enable these young men to draw one sure and one probable conclusion which they did not know before.

Not all relations make good tools for reasoning. If Mary and Jane both resemble Winifred, can you conclude that they resemble each other? You are likely to think so at first, till you notice that resemblance is not a precise enough relation to serve for purposes of indirect comparison. Mary may resemble Winifred in one respect, while Jane resembles her in another respect, and there may be no resemblance between Mary and Jane.

Abstraction. In comparing two things we ought to specify *in what respect* we are comparing them. In indirect comparison it is especially important to have the respect specified. Imagine a young child watching the procedure of comparing the heights of Mary and Jane by aid of marks on the wall. The child may not see the justice of the conclusion that both girls have, say, the same height. The child may object that the two girls are not the same, for one is fatter than the other, has darker hair, and runs faster. It has to be explained to him that only height is being considered, and it is something of an achievement for him to catch the point. The ability to compare two things in just one respect, *all other characteristics being disregarded*, is quite a remarkable trait of mankind. Without this abstracting ability man would never have developed his tools for indirect comparison, such as yardsticks, numbers and well-defined words. To *abstract* a certain characteristic of an object is to single out that characteristic and disregard all other characteristics in comparing

one object with another. "Abstraction" is the doing of this sort of thing. It has to be done in defining a class of objects, as we shall see later.

Abstraction is not always easy. In attempting to rate a person in one trait, it is not easy to avoid the "halo effect" (p. 145); it is not easy to disregard all his other traits. In attempting to compare two persons or things in one respect it is difficult to disregard all the other respects in which they are alike or different. And when you have compared two objects in one respect, you sometimes forget the limitations of your comparison and believe you have found them alike in various other respects. Errors of reasoning often result from failure of abstraction, as we shall see presently.

The syllogism. In many cases the data from which a conclusion is drawn can be put in the form of two statements, called *premises.* These premises and the conclusion are set down in compact form as an aid in checking the validity of the conclusion—in seeing whether it is implied by the premises. This device of logic is called a syllogism. Here is an example:

All mammals are warm-blooded.
All bears are mammals.
Therefore, all bears are warm-blooded.

The conclusion here is seen to be a genuine implication of the combined premises. This is an easy syllogism; many examples cannot be seen through so easily. Since they are often difficult, the difficulty lying not in gathering the data but in seeing their implications and drawing the conclusion, syllogisms make useful problems for examining this critical stage in the reasoning process. In one experiment the subjects were children of different ages (*2, 3*). Premises were given from which a certain conclusion was logical, and the age level of any particular syllogism was determined. By this means various problems were compared and certain sources of difficulty were discovered. Lack of familiarity with the topic of a problem is one obvious cause of failure to reason freely and surely. Another cause lies in an exces-

sive amount of material to be put together in reaching a conclusion. Especially confusing is the presence of irrelevant data which have to be thrust aside before the pattern of the pertinent data can take shape.

Another source of difficulty is the confused arrangement in which the data usually present themselves. They have to be rearranged by the reasoner before the conclusion can be seen. An instance is afforded by the efforts of eight-year-old children to solve the following problem of indirect comparison:

> Edith is fairer than Olive; but she is darker than Lily.
> Who is darker, Olive or Lily?

In this form the problem was solved correctly by only 46 percent of the 8-year group; but the percent of successes rose to 72 when a simple linguistic change was made, giving the same problem this form:

> Lily is fairer than Edith; Edith is fairer than Olive.
> Who is the fairer, Lily or Olive?

The difficulty with the first form was that the child found it necessary to turn the first premise around into "Olive is darker than Edith," before he could see the answer. The second form runs straight along, while the first form jerks back and forth because of the use of the two opposite relationship words, "fairer" and "darker."

Difficulty arises from another source that would not be suspected. If the conclusion is known to be true or false as a matter of fact, there is difficulty in seeing whether or not it follows from the given premises. Notice the following reasoning:

> All Mongolians have slant eyes.
> The Chinese have slant eyes.
> Therefore, the Chinese are Mongolians.

Over 50 percent of a group of college students marked this conclusion as correct. They would doubtless have responded quite differently to the same syllogism with changed terms, as for example:

All birds have wings.
Bees have wings.
  Therefore, bees are birds.

To escape from such confusing associations and pin oneself down to the data and their pattern, letters can be substituted for the meaningful terms of a syllogism. In place of either of the two just given, we should have:

All A is C.
B is C.
  Therefore, A is B.

But this device, though useful after practice, is rather a hindrance than a help to the uninitiated. Even college students, with all their training in algebra, commit more errors in these symbolic syllogisms than in those stated in ordinary language. They made, in one extensive experiment, 16 percent of errors in dealing with syllogisms expressed in familiar terms, as against 24 percent when exactly the same syllogisms were given in letter symbols (*19*).

Overcoming linguistic difficulties in reasoning. In these syllogism experiments, a large share of the difficulty arises from the fact that ordinary language is not well suited to present the exact data nor to formulate the pattern into which the data have to be thrown. This source of difficulty appears clearly when the problem involves only a single statement and asks what can be made out of that statement besides what is directly stated. Can the statement be "converted" by interchanging subject and predicate? Consider which of the following converted statements are implied in their respective original statements.

Original	*Converse*
(1) All X is Y	All Y is X
(2) Some X is Y	Some Y is X
(3) No X is Y	No Y is X
(4) Some X is not Y	Some Y is not X

Most subjects, students and others, find it easy to accept all of the converted statements, though careful examination

shows that only (2) and (3) are sound reasoning. From "All *X* is *Y*" it follows that "Some *Y* is *X*," but not that "All *Y* is *X*." The difficulty here is one of language. "All *X* is *Y*" has an *atmosphere* of strong positive assertion which misleads one into drawing a similar conclusion; and "Some

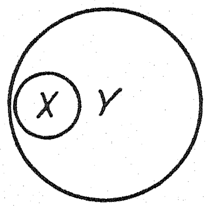

FIG. 105.—Diagram of the statement, "All X is Y."

X is not *Y*" has an atmosphere of weak negation which makes the similar conclusion seem all right (*14*).

That the difficulty in these cases is largely one of language is seen from the fact that a diagram may make everything clear. Consider once more the statement that "All *X* is *Y*."

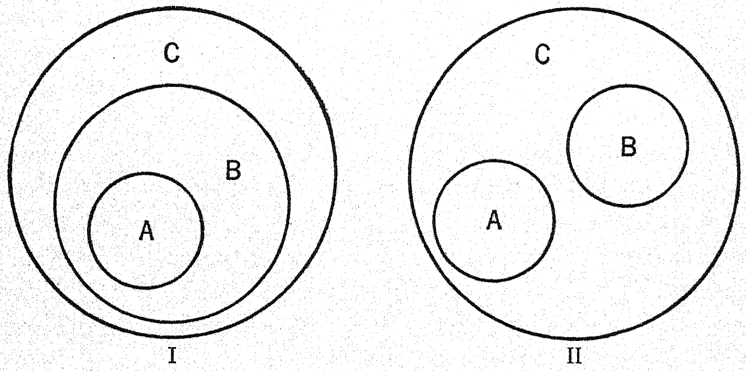

FIG. 106.—Diagrams of two syllogisms:
I: "All A is B; all B is C: therefore, all A is C"—valid.
II: "All A is C; all B is C: therefore, all A is B"—invalid.

Represent all *X*, the class *X*, by a circle, and the class *Y* by another circle. Then the statement is diagrammed by placing the *X* circle inside the *Y* circle. From the diagram we see at once that some, but not all *Y* is *X*. (The statement, "All *X* is *Y*," is however ambiguous, since it might mean

that the two classes were identical, as in definitions or synonyms; for example, "All aeroplanes are airplanes.")

To diagram a syllogism, three circles are needed. The syllogism about bears being warm-blooded because they are mammals, which are all warm-blooded, is readily seen to be sound reasoning (Fig. 106). If the *A* class is included in the *B* class, and the *B* class in the *C* class, then the *A* class must be included in the *C* class.

But the syllogism about Chinese being Mongolians because both are slant-eyed is seen to be fallacious. The premises here tell us that the *A* class and the *B* class are both included in the *C* class, but within the large class the two smaller classes might coincide, overlap or be entirely separate (Fig. 106).

This last syllogism is an instance of indirect comparison, the same as the case of the two students who discovered their fathers to be members of the same class of alumni. The students went on to utilize an additional though unstated premise, to the effect that all members of the same college class know each other, and their conclusion was legitimate under that assumption. But the students did not make the mistake of concluding that their two fathers were the same man; they did not say, "Therefore *A* is *B*." They knew well enough that they had compared their fathers in one respect only, that of class membership, and they did not lose sight of this abstraction. But when we hastily conclude from "*A* is *C*, and *B* is *C*" that therefore *A* is *B*, we are forgetting our abstraction. All we can conclude is that *A* and *B* are alike in respect to being *C*. We can conclude that Chinese and Mongolians are alike in having slant eyes, and that birds and bees are alike in having wings; but that is all the information our premises contain. This particular kind of fallacious reasoning is common in conversation and in oratory, largely because of the magic of words.

Syllogisms based on the relations of inclusion and exclusion are easily represented by the circle diagrams. The more-and-less syllogisms (like "*A* is bigger than *B; C* is smaller than *A;* therefore . . .") are easily diagrammed by points along

a straight line. The difficulty with these, too, is largely verbal in character. Once you get the data in diagram form, the conclusion or lack of sure conclusion stands out clearly.

Our own conclusion regarding the difficulties of the syllogism is that they are largely due to the ambiguity and irrelevant atmosphere of the words in which they are stated. Errors creep in because we try to think in words which do not clearly express the essential relations of the data, and which do carry a lot of misleading suggestions.

THOUGHT AND LANGUAGE

From time to time, for the past two thousand years, some psychologist has come forward with the hypothesis that thought is the same as inner speech. The primary evidence for this view is derived from introspection. Almost anyone will agree that he talks to himself, internally, when thinking over a difficult problem. If alone, he may talk aloud, with gestures. This common experience, along with the fact that man, the thinking animal, is also the talking animal, has led to the identification of thought with inner speech.

Language is certainly a great aid to thought. First and most important, thinking develops very largely out of *social* behavior. The child is stimulated to think by being questioned and by trying to explain his wants. Discussion and argument stimulate thought, and even when the individual is thinking all by himself he is apt to defend his conclusions before an imaginary audience.

Language helps in assembling materials for thought, because it is an aid in *recall.* Verbalized facts and principles are more readily recalled. If you put into words the principles found useful in solving one problem, you recall them more surely when you encounter a similar problem. A good stock of carefully formulated principles is essential for efficient reasoning in any difficult field.

Language is a system of *symbols* which can be substituted for facts and manipulated more handily than the facts themselves. Words not only aid thought, but also save thought.

Number words are the best illustration. Knowing the addition and multiplication tables—jingles of words, to a large extent—and following certain rules, we figure out number problems with a facility that is marvelous.

In spite of all that can be said in its favor, the thesis that thought = inner speech is probably wrong. In syllogistic reasoning, as we saw, language is in some respects a definite handicap to clear thinking. Because of the inadequacy and deceptiveness of the verbal forms, resort is had to diagrams. The geographer thinks in terms of maps, and the engineer in terms of blueprints, which are symbols indeed, but symbols put together according to the nature of the objective facts which they symbolize, and not according to the rules of language.

Introspection, which supports the proposition that much inner speech goes on in thinking, also shows that at certain times thought runs away from speech. When thought is very active, speech is apt to become fragmentary. Here are a few other facts indicating that thought cannot be identified with inner speech. You often think of an object without bothering to recall its name. Silent reading covers a page in half the time that would be required for pronouncing the words, however rapidly. In reading aloud, you get the sense of a word before the voice reaches that word, and so can give the thought proper expression. In speaking also, thought keeps ahead of the speech organs, so that you are thinking one thing while saying another. Thought, from all the indications, precedes speech and is not identical with it.

Talking does not insure thinking—that is certain. To say the words in which a thought is expressed is not sufficient. A boy learns his little speech thoroughly, goes on the platform and rattles it off without the slightest sense of what he is saying. If we were justified in writing any equation between thought and speech, it would have to read, not thought = speech, but thought = meaningful speech. Language is a system of signs, and thought deals with the meanings of the signs.

Thought and the muscles. It is quite another question, though again a question of much theoretical interest, whether thinking can go on without any muscular activity. Is it possible for the brain to act without discharging along the motor nerves into the muscles? Thinking may be an activity of the entire organism rather than purely a brain activity.

Recording apparatus applied to the tongue or larynx shows small movements occurring much of the time, during active thought or otherwise, but does not show what might be expected. One might expect to find during inner speech movements like those of whispering, only smaller, but the movements recorded during silent speech do not clearly show the pattern of speech movements (*17*). The reason may be, however, that the movements are so minute during silent speech that mechanical registration fails to catch them (*11*). When an electrode is inserted directly into the tongue muscle, so as to lead off the "action currents" of the muscle to a galvanometer, it is found that feeble action currents do occur when the subject silently counts or repeats a poem. If he imagines an arm movement there are action currents in the arm muscles (*9*). If he visualizes a large object or a moving object, his eyes are very apt to move (*18*).

Two inferences are apparently justified. First, thinking is commonly accompanied by muscular activity, not always in the speech organs. Second, the muscular activity in thought is often so much reduced as to require very delicate instruments for its detection.

CONCEPTS AND THEIR DEVELOPMENT

An important tool in thinking is the concept, which in more familiar language is the idea you have of anything. It is not any single memory image or motor response. Rather, the concept is the sum total of what you know about the object: how it looks, how it sounds, how it smells, tastes and feels to you, what it does and what you do to it. Your concept of anything is what the thing means to you. Anything

that can be perceived by the senses, thought of or imagined, can be conceived—persons, things, events, qualities and relations, concrete or abstract, individual or general.

Development of concepts in the little child. Until the child can talk, it is difficult to trace the development of his concepts, though he probably does some thinking and forms some concepts before he begins to talk. Very early he responds to the sight of a person by getting ready for what the person usually does to him, and as soon as he definitely *anticipates* what the person will do, he certainly has a rudimentary concept of that person. And so of things. As soon as he definitely anticipates the noise a spoon will make when dropped on the floor, he knows something about spoons and has a rudimentary concept of that class of objects. Therefore the child's behavior, even before he starts to talk, strongly suggests that he is already building up concepts. The child's concept of a thing centers around what he does with the thing and what it does to him.

When the child begins to understand words, and soon afterwards to say them, he is picking up the concepts current in his social environment, and we can judge, from his growing vocabulary, which of these concepts he acquires most readily. We note two factors of advantage in this early development of concepts. What stands out in sense perception has an advantage in concept formation, and what the child deals with in a practical way has an advantage.

Further development of the child's concepts. Interesting studies of children's concepts of the physical world, between the ages of three and twelve, have been made by listening to their questions, by demonstrating physical phenomena and by quizzing the children (*8, 12*). There seem to be two streams of the child's thought on physical matters, an animistic stream and a realistic or mechanistic stream. Animistically (or anthropomorphically) he reads something akin to his own desires, or something akin to the doings of men, into natural phenomena that are outside of his own field of practical activity. Realistically, within the field of his activity, he learns the common properties of physical objects,

such as weight and friction, and accepts them as matters-of-course that require no explanation. When children of different ages are asked what things are alive and can feel, their answers indicate a gradual development from animistic to more mechanistic conceptions of nature, passing through a series of stages which however are not closely bound up with definite ages, since some children progress in this respect much faster than others.

In the first stage, everything is alive and can feel:

Does a stone feel the cold? *No.*—Would it feel if it was dropped on the ground? *Yes, because it would break.*—Can a table feel anything? *No.*—Would it feel if it were being broken? *Oh, yes.*—Does the wind feel when it blows against a house? *Yes, because it is in its way. It can't pass. It can't go any further.*—Do walls feel? *No.* Why not? *Because they can't move.* Would they feel anything if they were knocked down? *Yes.*

In the second stage, anything can feel when it moves:

Does the sun know anything? *Yes, it heats.*—Does it know that it's hidden from us in the evening? *Yes, because it sees the clouds in front of it. . . . no, it doesn't know, because it isn't the sun that hides. It's the clouds that go in front of it.*—Does a bicycle know when it goes? *Yes, it feels the ground.*—Does a motor know it goes? *Yes, it feels it isn't still in the same place.*

In the third stage, things feel when they move *of themselves:*

Is a fly alive? *Yes, because if it wasn't alive it couldn't fly.*

Is a bicycle alive? *No, because it's we who make it go.*

Are clouds alive? *Yes—no, they're not. If they were alive, they would come and go as they wanted. It's the wind that drives them.*

Is the wind alive? *Yes, because it's the wind that drives the clouds.*

Are streams alive? *Yes, because the water is flowing all the time.*

Is an automobile alive? *No, it's the engine that makes it go.*

Is the engine alive? *No, it's man who makes the engine go.*

Is the sun alive? *Yes, it makes the sunshine and gives light.*

A further stage would be a mechanistic conception of the movements of all inanimate things, and this is about as far as most individuals go in this direction.

Egocentric and objective concepts. The difficulties with which the child labors in reaching objective concepts are well illustrated in the case of the apparent motion of the sun and moon. The child sees them move with him when he walks. It seems that he makes them move, or else that they follow him. This "egocentric" concept is flattering, and is also the easiest and most direct reading of the observed facts. The child has the same difficulties, in a small way, that the whole civilized world had about 1600 in giving up the man-flattering geocentric conception of the universe for the Copernican conception. It takes a wrench to conceive of the earth as being not the center of all things but only a small element in a much bigger system.

An egocentric concept is one which relates the object to the individual himself, while an objective concept relates one object to another. The child is led and driven to observe things acting upon each other, or otherwise related to each other, and so he makes a start in the formation of objective concepts. Egocentric concepts lie close to the individual's desires, but objective concepts are more practical, because they correspond better with things as they are and so enable the individual to extend his control over the environment.

The concept, to be a tool of successful thinking, has to "work." It has to work in the manipulation of objects, and is checked up by the physical environment; and it has to work in conversation with other people, and is checked up by the social environment. The physical environment insists on objectivity of concepts, and the social environment insists on their conformity with the accepted ideas of the group. By degrees, then, some of the child's concepts become objective, while others come to accord with the concepts of the culture in which he is growing up. These socially accepted concepts are often far from objective; in some cultures, for instance, animistic views of many natural phenomena are standard. In our own culture also, propaganda and other

sorts of social control prevent the individual from developing his own concepts freely and from being "intellectually honest."

Generalization of concepts. Since what is observed is always some particular ball or dog or person, the question arises how the child ever comes to his concepts of a class of objects —balls, dogs or persons in general. We might suspect that it would be a slow and difficult process for him to advance from concepts of this, that and the other particular dog to the concept of dogs as a class. But to quite an extent generalizing is the line of least resistance here, as in the conditioned response (p. 310). The child's spontaneous extension of the meaning of names reveals the ease with which he generalizes. He calls a strange man "papa." He reacts to the new object as he has learned to react to similar objects. He assimilates the new to the old and familiar (p. 469). Such is generalization of the easy sort, but to reach an intellectual concept of a class of objects, some freedom of thought from motor response is necessary.

A start towards this freedom is seen in what is called *association by similarity*. One thing makes you think of another similar thing that you have known. One person reminds you of another. Now if, on sight of a person who resembles your old friend, you impulsively rush up and grasp his hand, only to be received with wonder, that is simply a generalized response. But if you check your motor response and say to yourself that this stranger resembles your friend, that is association by similarity—a more complex response, since you are thinking of two people instead of only one, and since you are aware of some difference between them as well as of their resemblance. Association by similarity explicitly recognizes the likeness of objects that are not identical, and so leads to the concept of a class of similar objects. But another step, and a long one, is necessary before you can define this class and see exactly in what respect the objects are similar. Analysis is necessary.

Analysis and definition. To define a concept, you must discover what is common to all objects covered by the con-

cept, without being present in other objects that do not belong under the concept. A chair is "to sit on," but you can sit on other things. Chairs themselves vary in many ways, and any one chair has characteristics that do not belong in the concept of a chair. The difficulty is to peel off from a chair, in thought, something that does not come off physically, namely, the essential characteristics of a chair. It is a task of isolation or abstraction.

Two procedures are theoretically possible by which this isolation could be accomplished. One has been called *isolation by varying concomitants*, and might also be called, by a figure of speech, the "composite photography" process. The other may be called the method of *hypothesis and verification*, and is a form of the trial and error process.

In taking a composite photograph of 10 persons, you expose the plate one-tenth of the usual time for each successive individual, taking care to superimpose the faces as closely as possible. The composite shows a face with the common characteristics emphasized and the individual variations mostly lost. By analogy we can imagine an observer viewing one specimen after another of a given class of objects and gradually obtaining a generalized impression. The common features would come out strongly by virtue of frequency, and the varying concomitants would have little effect on the composite picture. After a person had seen a score or two of miscellaneous dogs he would be acquainted with dogs as a class, and know their class characteristics, even though he might still be unable to formulate his concept in words.

The trial and error process of discovering the essential characteristics of a class would be the same as was described a few pages back under the name of "verification." The observer does not simply wait for a general impression to form in him, but he makes a guess, forms a tentative concept, and tries it out on various specimens of the class. He sticks to this concept as long as it holds good, but is often forced to modify it or try another lead, just as in problem solution or scientific investigation.

These two theories of the process of concept formation have been tested to a certain extent by experiment. In one type of experiment a series of nonsense drawings is shown, all of them possessing certain common characteristics but differing in other respects. A nonsense name is assigned to this class of objects, and there are one or more other classes each with its nonsense name. The subject's task is to observe the drawings as they are shown, one at a time, and to evolve a definition of each class. Being very much on the alert in such an experiment, the subject seizes on some prominent feature of the first drawing and if he finds it in the second also looks for it in each successive drawing. As long as he finds it he regards it with more and more confidence as the common characteristic of the class. But if he cannot find it in one or more of the drawings, the intelligent subject promptly ceases to look for it and takes up some other feature. He proceeds by testing suggested hypotheses. At least, this trial and error procedure stands out prominently in his behavior (*6*, *15*, *16*).

This result leaves us however with the question, how the subject gets hold of hypotheses to test. The testing process is easily observed, objectively or introspectively, but the process by which a new hypothesis arises is very elusive. The subject's first hypothesis is suggested by some prominent feature of the objects, but when this lead turns out badly, how is another hypothesis found?

Some light is thrown on this question by a type of experiment in which the subject's task is to discover for himself the rule governing a simple game. He starts playing the game with no knowledge of the rule, meeting each new situation the best he can and being merely informed after each play whether it was right or wrong. He tries out hypothetical rules as they suggest themselves; but sometimes he feels completely at a loss, all his guesses having proved futile, and all he can do is to play at random and hope for some further hypothesis to suggest itself. In this receptive mood he is impressed by some similarity between the situations, some previously unnoticed similarity between those of his previous

plays that had been successful. Here, it would seem, the composite photography process is operating (7).

An individual who trusted entirely to the composite photography process for his concepts would encumber himself with many "half-baked" ideas. He would be the individual who accepts all his own "hunches" as gospel truth. Still, the hunch is not to be despised. In the right hands it becomes a hypothesis to be tested and may prove fruitful. How does it arise? Unless there were some process analogous to mental composite photography, only the most obvious hypotheses would suggest themselves. The whole process of concept formation must include both an elusive process of getting hypotheses and the more overt and manageable process of checking them against reality (4).

Summary of the chapter. Reasoning is a process of mental exploration—"mental" in that it uses materials not momentarily presented to the senses. Even when immersed in a present situation, the thinker operates with meanings derived from his past experience. The whole reasoning process includes four part-processes, not necessarily occurring in this order: gathering the data, combining them, seeing the implications of the combination, and testing the conclusion thus reached. Gathering the data has the pattern of trial and error rather than that of straightforward progress toward a goal. To combine the data so as to reveal their implications, some unifying idea is needed. Consideration of the motives that lead human beings to engage in reasoning brings out several types of situation that are handled in this way.

The seeing of implications amounts to finding relations in the data, and logic is an aid in distinguishing usable from unusable relationships. The syllogisms of logic, when expressed in ordinary language, are often puzzling because of ambiguities and misleading verbal suggestions. For this and other reasons it is not possible to accept the theory that identifies thought with inner speech, even though language is in some ways a great aid to thought.

Concepts are essential tools in thinking, and the development of concepts from early childhood up is an important

problem in the psychology of thinking. To advance from egocentric to objective views of the world is one step toward effective thinking. Generalization is fundamentally easy, but the analysis and abstraction required for valid general concepts is difficult. The process of reaching a general concept seems to involve an elusive process of getting a "hunch," followed by a more tangible process of testing it as a hypothesis is tested.

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Chapter XVII

Imagination

FROM discovery we now turn to invention, from exploration to manipulation.

The human enterprise of exploration, which we have been examining, runs the gamut from simple movements of looking and listening to the elaborate procedure of science in testing hypotheses and discovering laws of nature. Inventive activity runs a similar gamut from the child's play with his toys to the creation of a work of art or engineering or the organization of a new form of government. The distinction between the two lines of activity is that exploration seeks facts as they are, and manipulation aims at some change. The two enterprises go hand in hand, however; invention is based on science and science no less on invention.

For a preliminary, catch-word type of definition, we may say that imagination is *mental manipulation*. When the individual recalls facts previously observed in reality and then proceeds to rearrange these facts into a new pattern, he is said to show imagination. A product of imagination is composed of parts perceived at different times and later recalled and combined, as a centaur is composed of man and horse, and a mermaid of woman and fish. Imagination is like reasoning in using recalled facts; but while reasoning consists in seeing relations actually existing between the facts, imagination puts them into new relations.

Imagination and invention are much the same, though imagination means rather the mental process itself, and invention often the outcome of the process, which is a product having some degree of novelty and originality.

Imagination, like association, is sometimes free, and sometimes controlled (p. 33). Controlled imagination is directed to the accomplishment of some desired result, while free imagination wanders this way and that, with no fixed aim. Controlled imagination is seen in planning and designing; free imagination occurs in moments of relaxation, and may be called "play of the imagination." The playful sort of imagination is probably the more fundamental and the first to develop, and we may therefore assist ourselves toward an understanding of imagination by devoting some attention to play.

IMAGINATIVE PLAY

Manipulation and exploration certainly go hand in hand in the little child's play. The baby picks up his new toy, turns it about and examines it on all sides, shakes it and is pleased if it makes a noise, drops it and is pleased with its bang on the floor. In manipulating the toy he is exploring it and learning its properties.

Beginnings of imagination in the child. Beginning with grasping, turning, shaking and dropping of objects, the child's manipulation develops in several directions. One line of development leads to *manual skill.* Skilled movement develops out of the miscellaneous movements of play rather than by the combination of definite reflexes.

A second line of development is in the direction of *constructiveness.* Taking things apart and putting them together, block building, assembling dolls into "parties," are examples of this style of manipulation, which calls less for manual dexterity than for seeing ways in which objects can be rearranged.

Make-believe is a third direction followed in the development of manipulation. The little boy puts together a row of blocks and pushes it along the floor, asserting that it is a train of cars. The little girl lays her doll carefully in its bed, saying, "My baby's sick; that big dog did bite him." This amounts to manipulating things according to the *meanings*

attached to them, the blocks being treated as cars, and the doll as a sick baby.

Perhaps a little later than make-believe to make its appearance in the child is story-telling, the fourth type of manipulation. Where in make-believe he has an actual object to manipulate, in story-telling he simply talks about persons and things and makes them perform in his story. He comes breathless into the house with a harrowing tale of being pursued by a hippopotamus in the woods; or he gives a fantastic account of the doings of his acquaintances. For this he is accused of being a "little liar," or more charitably described as unable to distinguish observation from imagination; but really what he has not yet grasped is the *social* difference between his make-believe, which no one objects to, and his story-telling, which may lead people astray.

In such ways as we have been describing, the little child shows imagination or mental manipulation. In story-telling the objects manipulated are simply *thought of;* in make-believe, though there is motor manipulation of present objects, the attached *meanings* are the important matter; and in construction there is apt to be a *plan* in mind in advance of the motor manipulation. Thus play, usually if not always, contains an element of imagination. We may take the child's play as the first and simplest case of free invention and ask (a) what objects are suited to arouse playful activity, (b) in what the activity consists and what results it reaches, and (c) what may be its motivation.

Playthings. What, after all, is a toy? What characteristics of an object make it a real toy, which shall actually arouse the play response? We can approach this question empirically by assembling a list of toys, and classifying them from the psychological point of view. A large share of them fall into the following classes.

Movable objects: a book, door or drawer to open and shut, a water tap to turn on and off (especially on), a bag or box to pack and unpack. Almost anything that the child can move serves him as a plaything.

Plastic materials: damp sand, mud, snow; and other ma-

terials that can be worked in some way, like paper to tear or fold, blocks to pile or build, water to pour.

Noise-makers: rattle, drum, bell, horn, firecracker.

Vehicles, especially those providing unusual modes of locomotion: cart, bicycle, sled, skates, skipping-rope.

Space-annihilators enabling the child to act at a distance: balls to throw, bow and arrow, sling, mirror to flash light into the eyes of a distant person.

Things that defy gravity by floating, balancing or rising instead of falling: balloon, kite, boat, top, rolling hoop, swing, seesaw.

Adult-imitating toys: little tools, dishes, furniture, toy animals, dolls. Some psychologists have been so much impressed with the imitative play of children and animals (as illustrated by puppies playing fight), that they have conceived of all play as a sort of rehearsal for the serious business of life; but this conception does not apply very well to the other sorts of toy.

The play response. Play consists in manipulating or managing the plaything so as to produce some interesting result. The hoop is made to roll, the kite to fly, the arrow to hit something at a distance, the blocks are built into a tower or knocked down with a crash, the mud is made into a "pie," the horn is sounded. Many games are variations on pursuit and capture (or escape): tag, hide-and-seek, prisoner's base, blindman's buff, football. Wrestling, boxing, snowballing are variations on attack and defense. Action at a distance appears in golf, croquet, bowling, quoits, billiards, shooting. The element of manual skill enters into nearly all games. Mental acuteness appears in the guessing games, as well as in chess and cards. Many games combine several of the elements mentioned, as in baseball we have action at a distance, pursuit and escape, motor skill and activity, and a chance for "head work."

The play motives. No single "play instinct" furnishes all the motivation, but many sources of satisfaction are tapped. In the games that imitate fighting, some of the joy of fighting is experienced, even though no real anger develops. In the

games that imitate pursuit and escape, some of the joy of hunting and some of the joy of escape are awakened. In the kissing games that used to be common in young people's parties when dancing was frowned upon, and in dancing itself, sex gratification is present; but dancing also gives a chance for muscular activity which is obviously one source of satisfaction in the more active games. In fact, joy in motor activity must be counted as one of the most general sources of play-satisfaction. Another general element is the love of social activity, which we see in dancing as well as in nearly all games and sports.

The "escape motive" deserves a little more notice. Though you would say at first thought that no one could seek fear, and that this emotion could not possibly be utilized in play, yet a great many amusements are based on fear. The chutes, scenic railways, roller coasters, etc., of the amusement parks would have no attraction if they had no thrill; and the thrill means fear. You get some of the thrill of danger, though you know that the danger is not very real. Probably the danger itself would not be worth much, but being quickly followed by *escape*, it is highly satisfactory. The joy of escape more than pays for the momentary unpleasantness of fear. Fear is utilized also in coasting on the snow, climbing, swimming, or any adventurous sport: in all of them there is danger, but the skillful player escapes by his own efforts. If he lost control he would get a tumble; and that is why the sport is exciting and worth while. Nothing could be much further from the truth than to consider fear as a purely negative thing, having no positive contribution to make to human satisfaction. The fascination of gambling and of taking various risks probably comes from the satisfaction of the fear and escape motive.

But of all the "unlearned motives," it is mastery that comes in oftenest. Competition is utilized in a tremendous number of games and sports. Either the players compete as individuals, or they choose sides and compete as teams. No one can deny that the joy of winning is the high light of play. Yet it is not the whole thing, for the game may have been

worth while, even if you lose. Provided you can say, "Though I did not win, I played a good game," you have the satisfaction of having done well, which is the mastery satisfaction in its non-competitive form.

All toys that enable you to act at a distance, or to move rapidly, gratify the mastery impulse. Imitative play does the same, in that it enables the child to perform, in make-believe, the important deeds of adults. Children like to play at being grown-up, whether by wearing long dresses or by smoking, and you can observe how important they feel by the way they strut and swagger.

Empathy. There is still another *possible* way in which play may gratify the mastery impulse. Why do we like to see a kite flying? Of course, if it is *our* kite and we are flying it, the mastery impulse is directly aroused and gratified; but we also like to watch a kite flown by someone else, and similarly we like to watch a hawk, a balloon or aeroplane, a rocket. We like also to watch things that balance or float or in other ways seem to be superior to the force of gravity. Why should such things fascinate us? Perhaps because of *empathy*, the "feeling oneself into" the object contemplated. As sympathy means "feeling with," empathy means "feeling into," and the idea is that the observer identifies himself with the object observed, and gets some of the satisfaction from watching an object that he would get from *being* that object. Would it not be grand to be a kite, would it not be masterful? Here we stand, slaves of the force of gravity, sometimes toying with it for a moment when we take a dive or a coast, at other times having to struggle against it for our very lives, and all the time bound and limited by it—while the kite soars aloft in apparent defiance of all such laws and limitations. Of course it fascinates us, since watching it gives us, by empathy, some of the sense of power and freedom that seems appropriate to the behavior of a kite. Perhaps the fascination of fire is empathy of a similar sort; for fire is power.

Empathy must be regarded as a hypothesis, rather than as a proved fact, in watching the kite. In watching a fellow being perform a difficult feat, especially when one is eager

for him to succeed, empathy is often visibly manifested. Observe the spectators at an athletic contest or game and you will see some of them "help" a player who is on the point of

FIG. 107.—(From Allport's *Personality*, 1937.) Empathy in the well-wishing spectators of an athletic feat.

kicking the ball, or a pole vaulter who is just clearing the bar. Such behavior of the spectator is sometimes carelessly called imitative, which it cannot be since it tends to *precede* the player's movement. It is not doing what the player is observed to have done, but what the spectator imagines the player is about to do. The spectator is participating imaginatively.

Another instance of possible empathy will be noticed shortly.

Play as self-motivating activity. Play gives rise to situations that are interesting to the players, even when the interest cannot be traced to any "unlearned motive." The rhythm of dancing, marching, and of children's sing-song games can scarcely be traced to any such motive. The sociability of games goes beyond mere gregariousness, since it calls for acting together and not simply for being together; and at the same time it goes beyond competition and self-assertion, as is seen in the satisfaction the players derive from good team work.

If the self-assertive impulse of an individual player is too strongly aroused, he spoils the game, just as an angry player spoils a friendly wrestling match or snowball fight, and just as a thoroughly frightened passenger spoils a trip down the rapids, which was meant to be simply thrilling. Though the emotions and fundamental motives of life are active in play, they must not be too active. The game interest arises out of the game situation, just as other typically human interests arise from dealing with the environment (p. 395).

Playful behavior is strong evidence against that theory of all behavior which holds that it consists in seeking "equilibrium" or in removing stimulation. On this theory we eat to escape the hunger pangs, as we pull our hand away from a hot stove. The theory can be made to seem reasonable when applied to the reflexes and to many serious affairs of life, but it can scarcely hold good of play. One who goes out to play is seeking activity, and the game is so devised that each response leads not to equilibrium but to a situation calling for further response. A child, or an adult who has no conflicting duties, will play till he is fatigued, when, indeed, the seeking for equilibrium sets in.

DAYDREAMS

Daydreaming is distinctly a form of play, and the fact that it is so universal an amusement shows that mental activity, as

well as motor, is self-motivating. Yet personal motives can often be detected in a daydream. A daydream typically looks toward the future, as if planning for possible action; only, it is not a serious plan—which would be controlled imagination—nor necessarily a plan which could work in real life, but merely play of imagination.

Mastery daydreams. Daydreams usually have a *hero,* and that hero is usually the dreamer's self. Sometimes one is the conquering hero, and sometimes the suffering hero, but in both cases the recognized or unrecognized merit of oneself is the big fact in the story, so that the mastery motive is evidently finding satisfaction here as well as in other forms of play. Probably the conquering hero dream is the commoner and healthier variety. A classical example is that of the milkmaid who was carrying on her head a pail of milk she had been given. "I'll sell this milk for so much, and with the money buy a hen. The hen will lay so many eggs, worth so much, for which I will buy me a dress and cap. Then the young men will wish to dance with me, but I shall spurn them all with a toss of the head." Her dream at this point became so absorbing as to get hold of the motor system and call out the actual toss of the head—but we are not after the moral just now; we care simply for the dream as a very true sample of many, many daydreams. Such dreams are a means of getting for the moment the satisfaction of some desire, without the trouble of real execution; and the desire gratified is very often some variety of self-assertion. Sometimes the hero is not the dreamer's self, but someone closely identified with the self. The mother gratifies her pride in her son by making him her daydream hero.

The "suffering hero" daydream seems at first thought inexplicable, for why should anyone picture himself as having a bad time, as misunderstood by his best friends, ill-treated by his family, jilted by his best girl, unsuccessful in his pet schemes? Why should anyone make believe to be worse off than he is; what satisfaction can that be to him? Certainly, one would say, the mastery motive could not be active here.

And yet—do we not hear children *boasting* of their misfortunes? "Pooh. That's only a little scratch; I've got a real deep cut." My cut being more important than your scratch makes me, for the moment, more important than you, and gives me a chance to boast over you. Older people are known sometimes to magnify their own ailments, with the apparent aim of enhancing their own importance. Perhaps the same sort of motive underlies the suffering hero daydream.

I am smarting, let us suppose, from a slight administered by my friend; my wounded self-assertion demands satisfaction. It was a very little slight, and I should make myself ridiculous if I showed my resentment. But in imagination I magnify the injury done me, and go on to picture a dreadful state of affairs, in which my friend has treated me very badly indeed, and perhaps deserted me. Then I should not be ridiculous, but so deeply wronged as to be an important person, one to be talked about; and thus my demand for importance and recognition is gratified by my daydream.

Usually the suffering hero pictures himself as in the right, and animated by the noblest intentions, though misunderstood, and thus further enhances his self-esteem; but sometimes he takes the other tack and pictures himself as wicked—but as very, very wicked, a veritable desperado. It may be his self-esteem has been wounded by blame for some little meanness or disobedience of his own, and he restores it by imagining himself a great, big, important sinner instead of a small and ridiculous one. In adolescence, the individual's growing demand for independence is often balked by the continued domination of his elders, and he rebelliously plans quite a career of crime for himself. He'll show them! They won't be so pig-headedly complacent when they know they have driven him to the bad. You can tell by the looks of a person whose feelings are hurt that he is imagining something; usually he is imagining himself either a martyr or a desperado, or some other kind of suffering hero. The suffering hero daydream is a substitute for a fight or some other

active self-assertion. The conquering hero daydream is often motivated in the same way; for example, our friend the milkmaid would not have been so ready to scorn the young men with a toss of the head if she had not been feeling her own actual inferiority and lack of fine clothes. The daydream makes good, in one way or another, for actual inability to get what we desire.

Other motives in daydreams. The desire which is gratified in the play of imagination belongs very often indeed under the general head of self-assertion; but when one is in love it is apt to belong under that head. Love dreams of the agreeable sort need no further motivation; but the unpleasant, jealous type of love dream is at the same time a suffering hero dream, and certainly involves wounded self-assertion along with the sexual impulse. Probably the self-asserting daydream is the commonest variety, take mankind as a whole, with the love dream next in order of frequency. But there are many other sorts. There is the humor daydream, illustrated by the young person who suddenly breaks into a laugh and when you ask why replies that she was thinking how funny it would be if, etc., etc. She is very fond of a good laugh, and not having anything laughable actually at hand proceeds to imagine something. So, a music lover may mentally rehearse a piece when he has no actual music to enjoy; and if he has some power of musical invention, he may amuse himself, in idle moments, by making up music in his head; just as one who has some ability in decorative design may fill his idle moments by concocting new designs on paper. When vacation time approaches, it is hard for anyone, student or professor, to keep his thoughts from dwelling on the good times ahead, and getting some advance satisfaction. Thus all kinds of desires are gratified in imagination.

Worry. Do we have fear daydreams, as we have amusements utilizing the fear and escape motive? Yes, sometimes we imagine ourselves in danger and plan out an escape. One individual often amuses himself by imagining he is arrested and accused of some crime, and figuring out how he could

establish an alibi or otherwise prove his innocence. But fear daydreams also include *worry,* which seems at first to be an altogether unpleasant state of mind, forced upon us and not indulged in as most daydreams are. Yet, as the worry is often entirely needless, it cannot be forced upon a person, but must have some motive. There must be some satisfaction in it, in spite of all appearance.

Some abnormal cases of worry suggest the theory that the fear is but a cloak for unacknowledged desire. Take this extreme case. A young man, "tied to the apron-strings" of a too affectionate and too domineering mother, has a strong desire to break loose and be an independent unit in the world; but at the same time, being much attached to his mother, he is horrified by this desire. She goes on a railroad journey without him—just an ordinary journey with no special danger—but all the time she is away he is in an agony of suspense lest the train may be wrecked. Such an abnormal degree of worry calls for explanation. Well—did not the worry perhaps conceal a wish, a wish that the train *might* be wrecked? So he would be set free without any painful effort on his part; and he was a young man who shrank from all effort. The psychopathologist who studied the case concluded that this was really the explanation of the worry.

If, however, we take such extreme cases as typical and cynically apply this conception to all worries, we shall make many mistakes. A student worries unnecessarily about an examination; therefore, he desires to fail. A mother worries because her child is late in getting home; therefore, she wants to be rid of that child. Thus, by being too psychopathological, we reach many absurd conclusions in everyday life; for it is the child that is loved that is worried over, and it is the examination that the student specially wishes to pass that he fears he has flunked.

Worry is a substitute for real action when no real action is possible. The student has done all he can do; he has prepared for the examination, and he has taken the examination; now there is nothing to do except wait; so that the rational

course would be to dismiss the matter from his mind; if he cannot accomplish that, but must do something, the only thing he can do is to speculate and worry. So also the mother, in her uncertainty regarding her child, is impelled to action, but there is nothing to do, except in imagination. Worry is fundamentally due to the necessity of doing something with any matter that occupies our mind; it is an imaginative substitute for real action.

But worry may be something of an indoor sport as well. Consider this—if the mother really believed her child had fallen into the pond, she would rush to pull him out. Really she expects to see him come home any minute, but by conjuring up imaginary dangers she is getting ready to make his home-coming a great relief instead of a mere humdrum matter. She is getting the thrill of danger with escape fully expected.

Use and abuse of daydreams. The normal time for a daydream is the time when there is no real act to be performed. A strong man uses it as the amusement of an idle moment and promptly forgets it. But one who is lacking in force, especially the personal force needed in dealing with other people, may take refuge in daydreams as a substitute for real doing. Instead of hustling for the money he needs he charms himself like Micawber, imagining the good opportunities that may turn up. Instead of going and making love to the lady of his choice, he shyly keeps away from her and merely dreams of winning her. He substitutes imaginary situations for the real facts of his life, and gratifies his mastery motive by imaginary exploits. He invents imaginary ailments to excuse his lack of real deeds. He conjures up imaginary dangers to worry over. All this is abuse of imagination.

DREAMS

Let us turn from daydreams to dreams of the night. These also are play of imagination, even freer from control and criticism than the daydream. In sleep the brain activity sinks to a low level, and perhaps ceases altogether in the deepest

sleep. Most of the dreams that are coherent enough to be recalled probably occur just after going to sleep or just before waking up, or at other times when sleep is light. At these times the simpler and more practiced functions, such as recall of images, can go on, while criticism, good judgment, reasoning, and all that sort of delicate and complex activity, are beyond the sleeper's power. Daytime standards of probability, decorum, beauty, wit, and excellence of any sort are in abeyance; consistency is thrown to the winds, the scenes being shifted in the middle of a speech, and a character who starts in as one person merging presently into somebody else. Dreams follow the definition of imagination or invention, in that materials recalled from different contexts are put together into combinations and rearrangements never before experienced. The combinations are often bizarre and incongruous.

Seeming reality of the dream. Perhaps the most striking characteristic of dreams is their seeming reality while they last. They seem real in spite of their incongruity, because of the absence of critical ability during sleep. In waking life, when the sight of one object reminds me of another and calls up an image of that other, I know that the image is an image, and that I have thought of two different things. In sleep the same recall by association occurs, but the image is forthwith accepted as real; and thus a person who reminds us of another person forthwith becomes that other person. We are not mentally active enough in sleep to hold our images apart. Associative recall, with blending of the recall material, and with entire absence of criticism, describes the process of dreaming.

The stimulus to which the dream responds. Sometimes there is an actual sensory stimulus, like the alarm clock or a stomach-ache; and in this case the dream comes under the definition of an illusion; it is a false perception, more grotesquely false than most illusions of the day. A boy wakes up one June morning from a dream of the Day of Judgment, with the last trumpet pealing forth and blinding radiance all

about—only to find, when fully awake, that the sun is shining in his face and the brickyard whistle blowing the hour of 4.30 A.M. This was a false perception. More often, a dream resembles a daydream in being a *train of thoughts and images* without much relation to present sensory stimuli; and then the dream would come under the definition of hallucination instead of illusion.

Sometimes a sensory stimulus breaks in upon a dream that is in progress, and is interpreted in the light of this dream. In one experiment (*14*) the dreamer, who was an authoress, was in the midst of a dream in which she was discussing vacation plans with a party of friends, when the experimenter disturbed her by declaiming a poem; in her dream this took the form of a messenger from her publisher, reciting something about a contract which seemed a little disturbing but which she hoped (in the dream) would not interfere with her vacation. Maury, an early student of this topic, was awakened from a feverish dream of the French Revolution by something falling on his neck; this, under the circumstances of his dream, he took to be the guillotine.

Motivation of dreams. What satisfaction does a dream bring to the dreamer? Or shall we say that it is merely a mechanical play of association, with no motivation in it? Dreams are interesting while they last, sometimes fearful, sometimes angry, sometimes amorous, otherwise not very emotional but distinctly interesting, so that many people hate to have a dream broken up by awaking. It seems likely, then, that dreams are like daydreams in affording gratification to desires. They are "wish-fulfilling," to borrow a term from Freud's theory of dreams, soon to be considered.

A boy dreams repeatedly of finding whole barrels of assorted jackknives, and is bitterly disappointed every time to awake and find the knives gone. An adult frequently dreams of finding money, first a nickel in the dust, and then a quarter close by, and then more and more, till he wakes up and spoils it all. Such dreams are obviously wish-fulfilling, as are also the sex dreams of sexually abstinent persons, or the feasting dreams of starving persons, or the polar explorer's recurring

dream of warm, green fields. An eminent psychologist (2) has given a good account of a dream which he had while riding in an overcrowded compartment of a European train, with the window closed and himself wedged in tightly far from the window. In this uncomfortable situation he dropped asleep and dreamed that he had a seat next to the window, had the window open and was looking out at a beautiful landscape. In all these cases *the wish gratified in the dream is one that has been left unsatisfied in the daytime.* The desires that are satisfied during the day do not demand satisfaction in dreams; but any desire that is aroused during the day without being able to reach its conclusion is likely to come to the surface in a dream.

The mastery motive, so prominent in daydreams, can be detected also in many sleep dreams. The gliding or flying dream, which many people have, reminds us of the numerous toys and sports in which defiance of gravity is the motive; and certainly it gives you a sense of power and freedom to be able, in a dream, to glide gracefully up a flight of stairs, or step with ease from the street upon the second-story balcony.

But there are unpleasant dreams, as well as pleasant. There are fear dreams, as well as wish dreams. A child who is afraid of snakes and constantly on the alert against them when out in the fields during the day dreams repeatedly of encountering a mass of snakes and is very much frightened in his sleep. Another child dreams of wolves or tigers. A person who has been guilty of an act from which bad consequences are possible, dreams that those consequences are realized. The officer suffering from nervous war strain, or "shell shock," often had nightmares in which he was attacked and worsted by the enemy.

A large share of dreams do not fit easily into any of the classes already described. They seem too fantastic to have any personal meaning. Yet they are interesting to the dreamer, and they would be worth going to see if they could be reproduced and put on the stage. Isn't that sufficient excuse for them? May they not be simply a free play of

imagination that gives interesting results just because of its freedom and vividness?

Freud's theory of dreams. Just at this point we part company with Freud, whose ideas on dreams as wish-fulfillments we have been following in the main (*3*). Not that Freud would have approved our account of dreams up to this point. Far from it. It would have seemed to him on too superficial a level altogether, dealing as it does with conscious wishes and with straightforward fulfillments. It has left out of account the "Unconscious" and its symbolisms.

The Unconscious, according to Freud, consists of forbidden wishes—wishes forbidden by the moral and social standards of the individual. A repressed wish does not peaceably leave the organism, but sinks to an unconscious state in which it is still active and liable to make itself felt in ways that are disguised and symbolic. An abnormal worry is such a disguise, a queer idea that haunts the nervous person is another, "hysterical" paralysis or blindness is another (pp. 349, 393).

In normal individuals the dream life was held by Freud to be the chief outlet for the repressed wishes. Even in dreams they dare not show themselves in their true shape and color, but disguise themselves in innocent-appearing symbolism.

Freud insisted that all dreams are wish-fulfillments, even those that seem mere fantastic play of imagination, since, as he saw it, no mental activity could occur except to gratify some wish. Further, he held, most adult dreams are fulfillments of the repressed wishes of childhood which are either sex or spite wishes, the spite wishes growing out of the interference of other people with our sex wishes.

While the psychoanalytic school of Freud regards the dream of an adult as an embodiment of some experience of childhood and a disguised fulfillment of the child's desire, the related schools of Adler (*1*) and of Jung (*5*) take a different view. According to Adler the dream is not a revival of the distant past but a rehearsal for some impending action which the individual has to perform, and the dream, properly analyzed, reveals the individual's characteristic mode of at-

tack on his problems. For Jung, the dream is related to the individual's present difficulties and reveals his unconscious attitude towards his life problems.

An objection to all these theories is that they fail to take account of the easy-running recall mechanism. We need not look for big, mysterious driving forces, when we know that *A* makes you think of *B*, and *B* of *C*, with the greatest ease. The dreamer isn't laboring, he is idly playing, and his images come largely by free association, with personal desires giving some steer.

AUTISTIC THINKING

Dreaming, whether awake or asleep, is free imagination. It does not have to check with any standard. So long as it is interesting, it serves its purpose. Sometimes the daydreamer exercises some control, breaking off a spiteful or amorous dream because he thinks it had better not be indulged; but in this he ceases to be simply a daydreamer. Daydreaming, by itself, is an example of what is called "autistic thinking," which means thinking which does not care about the real world. Autistic thinking gratifies some desire and that is enough for it. It does not submit to criticism from other persons nor from the individual himself, nor does it seek to square itself with reality. It is distinctly "wishful thinking."

Autistic thinking, indulged in by every imaginative person in moments of relaxation, is carried to an absurd extreme by some types of insane individuals. One type withdraws so completely from reality as to be inaccessible in conversation, unresponsive to anything that happens, entirely immersed in inner imaginings. Others, while living in the world about them, transform it into a make-believe world by attaching meanings to things and persons to suit themselves. This institution, in which the subject is confined, is his royal palace, the doctors are his officials, the nurses his wives, "thousands of them, the most beautiful women in creation." Or the delusion may take the line of the suffering hero, the subject

imagining himself a great man shut up in this place by the machinations of his enemies; the doctors are spies and enemy agents, and the nurses also act suspiciously; his food is poisoned, and he is kept in a weak and helpless condition, all out of fear of him. It is impossible to argue the patient out of his delusions by pointing out to him how clearly they conflict with reality; he evades the evidence by some counter-argument, no matter how flimsy, and sticks to his dream or make-believe.

Autistic thinking is contrasted with realistic thinking, which seeks to check with real facts; it may be contrasted also with socialized thinking, which submits to the criticism of other people; and it may even be contrasted with self-criticized thinking, in which the individual scrutinizes what he has imagined, to see whether it is on the whole satisfactory to himself, or whether it simply gratifies a momentary impulse running counter to more permanent desires.

INVENTION AND CRITICISM

"Criticism"—the word has been used repeatedly, and it is time it gave an account of itself. One desire gets criticized by running afoul of another desire, one idea by conflicting with another idea. We concoct a fine joke to play on our friend; but then the thought comes to us that he may not take it kindly; we don't want to break with our friend, and so we regretfully throw our promising invention on the scrap heap. That is self-criticism, the balancing off of one impulse by another. Self-criticism is obnoxious to the natural man, who prefers to follow out each desire till it reaches its goal; but he learns self-criticism in the hard school of experience. For plenty of criticism is directed at the individual from without.

Criticism assails him from the world of objective things, as soon as he tries to carry out what he has imagined. Often his invention will not work, his plan does not succeed, and he must cast it away and think up a new one. At this point the "weak brother" gives up trying, and takes refuge in

autistic thinking, but the stronger individual accepts the challenge of reality. He sees that an invention is not satisfactory unless it will work, and sets about learning what will work and what will not, so accumulating observations that later enable him to criticize his own ideas, before trying them out on real things.

Criticism assails the individual from the world of people, who, from the day he first begins to tell his childish imaginings, are quite free with their objections. Humiliated by this critical reception of his ideas, he resolves to keep them to himself for the future, and seeks refuge in autistic thinking; or, more forcefully, he exerts himself to find some idea that will command the approval of other people. If he can take rebuffs good-naturedly, he soon finds social criticism a great help, and two heads better than one in planning any invention. He accumulates knowledge of what will pass muster when presented to other people, and thus again learns self-criticism.

Self-criticism is helped by such rules as to "think twice," to "sleep on it before deciding," to "drop the matter for a time and come back to it and see whether it still looks the same." When you are all warmed up over an idea, its recency value gives it such an advantage over opposing ideas that they have no chance, for the moment, of making themselves felt in the line of criticism.

The great psychologist, and great writer, William James, once made a remark that threw some light on his mode of writing. In the evening, he said, after warming up to his subject, he would write on and on till he had exhausted the lead he was following, and lay the paper aside with the feeling, "Good! Good! That's good." The next morning, he added, it might not seem good at all. This calls to mind the old advice to writers about its being "better to compose with fury and correct with phlegm than to compose with phlegm and correct with fury." The phlegmatic critical attitude interferes with the enthusiastic inventive activity. Give invention free rein for the time being, and come around with criticism later.

Some overcautious and too self-critical persons, even though fertile in ideas, never accomplish much in the way of invention because they cannot let themselves go. Criticism is always at their elbow suggesting doubts and alternatives and preventing progress in the creative activity, instead of biding its time and coming in to inspect the completed result. For a similar reason, much of the best inventive work—writing, for example, or painting—is done in prolonged periods of intense activity, which allow time for invention to get warmed to its task, when it takes the bit in its teeth and dashes off at a furious speed, leaving criticism to trail along behind.

Invention in the service of art or of economic and social needs is controlled imagination, realistic, socialized, subjected to criticism. It cannot afford to be autistic, but must meet objective or social standards. Mechanical inventions must work when translated into matter-of-fact wood and iron, and must also pass the social test of utility. Social inventions of the order of institutions, laws, political platforms and slogans, plans of campaign, must work in the sense of bringing the desired response from the public. Social imagination of the very important sort suggested by the proverbs, "Seeing ourselves as others see us," or "Putting ourselves in the other fellow's place"—for it is only by imagination that we can thus get outside of our own experience and assume another point of view—must square with the real sentiments of other people.

THE ENJOYMENT OF IMAGINATIVE ART

It requires imagination to enjoy art as well as to produce it. The novelist describes a character and you, the reader, respond by putting together the items in the description so as to conceive of a character you have never met. The painter groups his figures before you, but you must get the point of the picture for yourself. The musical composer provides a sequence of notes, but you must get the pattern of the passage for yourself, and if he has introduced a novel

effect, it may not be easy to find any beauty in it on the first hearing.

Art, from the consumer's side, is play. It is play of the imagination, with the materials conveniently presented by the artist. Now, as art is intended to appeal to a consumer (or enjoyer), the question as to sources of satisfaction in the enjoyment of art is fundamental in the whole psychology of art, production as well as consumption.

Motivation of novel-reading. We have the same questions to ask regarding the enjoyment of a novel as regarding a daydream. Novel-reading is daydreaming with the materials provided by the author, and gratifies the same motives. A novel to be really popular must have a genuine hero or heroine—someone with whom the reader can identify himself. Novels in which the hero or heroine is a person of high rank, or wins rank or wealth in the course of the story, make an obvious appeal to the mastery motive. The humble reader is tickled in his own self-esteem by identifying himself with the highborn or noble or beautiful character in the story. The escape motive is relied upon to furnish the excitement of the many novels which bring the hero into danger or difficulty and finally rescue him, much to the reader's relief. Love stories appeal, of course, to the sex impulse, humorous stories to laughter, and mystery stories to curiosity. Cynical stories, showing the "pillars of society" in an ignoble light, appeal to the self-assertive impulse of the reader, who is led to apply their teaching to certain pretentious people and set them down a peg, to his own relative advancement. But here again, as in discussing sports and daydreams, we have to insist that interests of a more objective kind also are gratified by a good work of fiction. A story that runs its logical course to a tragic end is interesting as a good piece of workmanship, and as an insight into the world. We cannot heartily identify ourselves with Hamlet or Othello, yet we should be sorry to have those figures erased from our memories; they mean something, they epitomize world facts that compel our attention.

The appeal of art is partly emotional. A great work of art, the Apollo Belvedere or the Sistine Madonna, when you suddenly come upon it in walking through a gallery, may move you almost to tears. Beautiful music, and not necessarily sad music either, has the same effect. Why this particular emotion should be aroused is an enigma. "Crying because you are so happy" is similar but itself rather inexplicable. In many other cases, the emotional appeal of art is easily analyzed.

Art makes also an intellectual appeal. Many great works of art require mental effort in order to appreciate them. You must be wide-awake to follow a play of Shakespeare; you must puzzle out the meaning of a group painting before fully enjoying it; and music may be too "classical" to grasp and follow easily. Unless the artist has made a great mistake, this mental activity which he demands from his public must contribute to the satisfaction they derive from his works. If his appeal were simply to their emotions, any intellectual labor would be a disturbing element. The intellectual appeal is partly to objective interests in the thing presented, partly to interest in the artist's workmanship, and partly to the mastery motive, the zest for overcoming obstacles and solving problems.

Perhaps we do not often think of a fine painting or piece of music as a problem set us for solution, but it is that, and owes part of its appeal to its being a problem. If the problem presented is too difficult for us, the work of art is dry; if too easy, it is tame.

The mastery motive may be as important in the enjoyment of art as it seemed to be in play and in dreaming. It comes in twice: once in the joy of solving the problems presented by the work of art, and again in identification with the fine characters portrayed.

Empathy in art enjoyment. At first thought, some forms of art seem incapable of making the just-mentioned double appeal to the mastery motive. Architecture can certainly present problems for the beholder to solve, but how can the beholder possibly identify himself with a tower or arch? If,

however, we remember the "empathy" that we spoke of under the head of play, we see that the beholder may project himself into the object, unintentionally of course, and thus perhaps get satisfaction of his mastery impulse.

Look at a pillar (Fig. 108), for example. If the pillar is too massive for the load supported, it gives you the unsatisfactory impression of doing something absurdly small. If it is too slender for the load that seems to rest upon it, you get the feeling of strain and insecurity; but if it is rightly proportioned, you get the feeling of a worthy task successfully accomplished. The pillar, according to the empathy theory, pleases you by arousing and gratifying your mastery impulse; and many other architectural effects can be interpreted in the same way.

Empathy can perhaps explain the appeal of the *big* in art and nature. In spite of all the warnings put forth against thinking of mere bigness as great or fine, we must admit that size makes a strong appeal to something in human nature. Big trees, lofty cliffs, grand canyons, gigantic waterfalls, huge banks of clouds, the illimitable expanse of the sea, demonstrate cogently the appeal of the big. Perhaps the big is not necessarily grand, but the grand or sublime must be big or somehow suggest bigness. The question is, then, what it is in us that responds to this appeal.

Perhaps a submissive attitude is aroused. This great mountain, so far outclassing me, affords me the joy of willing submission. The escape motive may come in along with submissiveness—at the first sight of the mountain a thrill of fear passes over me, but I soon realize that the mountain will not hurt me in spite of its awe-inspiring vastness; so that my emotion is blended of the thrill of fear, the relief of escape and the humble joy of submission. That is one analysis of the esthetic effect of bigness.

Empathy suggests a very different analysis. According to this, projecting myself into the mountain, identifying myself with it, I experience the sensation of how it feels to be a mountain. It feels big—I feel big. My mastery impulse is gratified. To decide between these two opposing interpre-

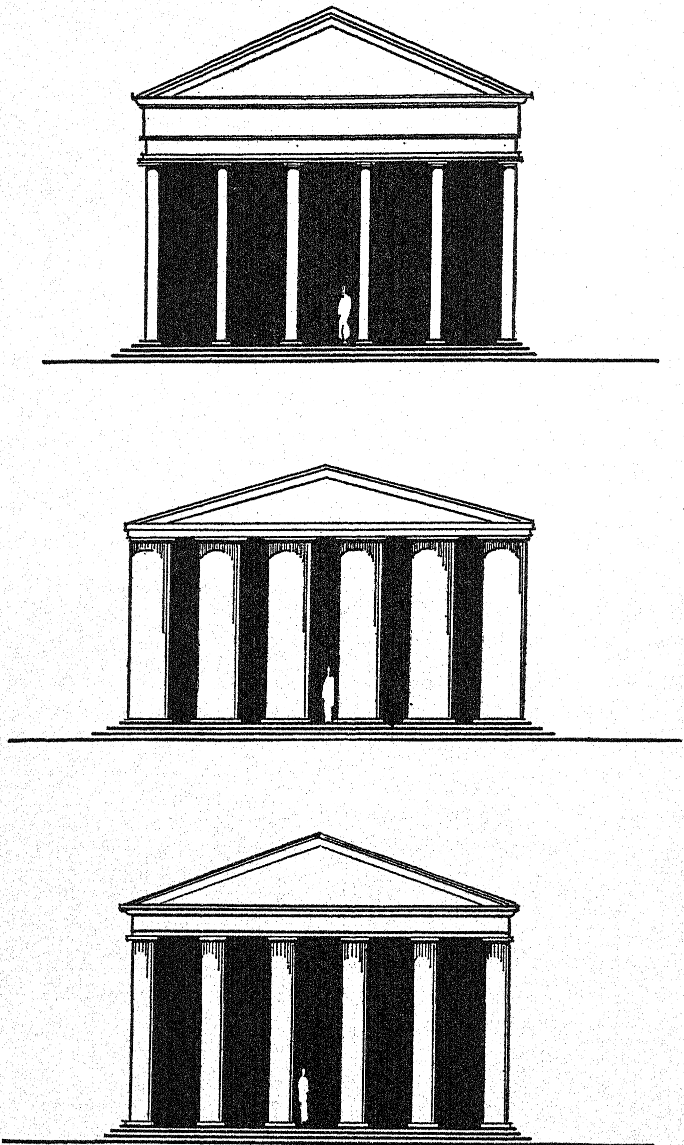

FIG. 108.—Empathy may explain the esthetic effect of suitable and unsuitable proportions in architecture.

tations ought to be possible from the behavior or introspection of a person in the presence of some big object. If he feels insignificant and humble and bows reverently before the object, we may conclude that a submissive attitude is aroused; but if the sight of the grand object makes him feel strong and fine, if he throws out his chest and a gleam comes into his eye, everything looks like the mastery motive. Quite possibly, the effect varies with the person and the occasion.

Beauty and ugliness can be seen in the very simplest objects, too. You would scarcely suppose that a mere rectangle could produce any esthetic effect; yet it is found that some rectangles are preferred to others, and that the popular choice falls along near the proportion known to art theorists as the "golden section," the width being about 62 percent of the length. Again, however much you may like symmetry, you can scarcely suppose it makes much difference exactly where a horizontal line is cut by a short cross line; yet nearly everyone on being put to the test selects the middle as the best point. Though the causes of these preferences are not surely known, we may hazard the conjecture that they are radically different in the two cases. Symmetry probably appeals to us, directly or indirectly, because we ourselves are symmetrical. We are symmetrical from side to side and we like a cathedral to be so, not insisting that it be symmetrical from front to back. On the other hand we are much slimmer than the golden section, and our preference here must have a less personal, more objective basis. Probably the golden section rectangle appears typical for a rectangle, slim enough to be a successful rectangle without being extreme. There is a suggestion here of two ways of perceiving objects: either in relation to ourselves, or in relation to other objects—either egocentrically or objectively (p. 553). There is no reason to assume that all esthetic interest springs from the internal needs of the organism. It may spring as well from the individual's interest in the objective world.

We may think of art as a great system or collection of inventions that owes its existence to its appeal to human nature, and that has found ways, as its history has progressed,

of making its appeal more and more varied. Art is a type in these respects of many social enterprises, such as sport, amusement, and even politics and industry. Each of these is a collection of inventions that persists because it appeals to a variety of human impulses.

THE PSYCHOLOGY OF INVENTIVE PRODUCTION

To the consumer, art is play, but to the producer it is work, in the sense that it is directed toward definite ends and has to stand criticism. What is true of the producer of art works is true also of other inventors, and we may as well consider all sorts of controlled imagination together.

In spite of the element of control that is present in productive invention, the really gifted inventor makes play of his work. He does not always have his eyes fixed on the financial goal, nor on the appeal of his inventions to the public. It is astonishing to read in the lives of inventors (*15*) what a lot of comparatively useless contrivances they busied themselves with, apparently from the pure joy of inventing. One prolific writer said that he "never worked in his life, only played." The inventor likes to manipulate his materials, and this playfulness has something to do with his originality, by helping to keep him out of the rut.

That "necessity is the mother of invention" is only half of the truth; it points to the importance of a directive tendency, but fails to show how the inventor manages to leave the beaten path and really invent. Necessity, or some desire, puts a question, without which the inventor would not be likely to find the answer; but he needs some flexibility or playfulness, just because his job is that of seeing things in a new light. We must allow him to toy with his materials a bit, and even to be a bit "temperamental," and not expect him to grind out works of art or other inventions as columns of figures are added.

When inventive geniuses have been requested to indicate their method, they have been able to give only vague hints. How does the musical composer, for example, free himself

of all the familiar pieces and bring the notes into a fresh arrangement? All that he can say is usually that he had an "inspiration"; the new air simply came to him. Now, of course, the air did not really come to him from outside; he made it himself, it was his reaction, but it was a quick, free reaction, of which he could observe little introspectively.

Framework and filling. Imagination is sometimes said to consist in putting together materials from different sources, but this is only half of the story. Thinking of a man and also of a horse is not imagining a centaur; there is a long jump from the mere juxtaposition of the materials to the meaningful whole. Typically the meaningful whole is present, in an embryonic state, before all of the materials are assembled, and the materials are sought because they are needed for filling out the existing whole. A framework is invented and data are assembled to fit into the framework. The plot of the story is outlined before the various incidents are worked out.

We must not make this scheme of the inventive process too hard and fast. The framework itself may grow and be modified by the parts that are fitted into it. Two stories may have the same plot in bare outline but differ considerably because of the differing incidents and characters that are woven in. "Fitting parts into a pre-existing framework," then, is not quite so adequate a formula for the inventive process as the phrase which we used before to describe the development of the organism (p. 211): "the interaction of parts" within a pre-existing whole.

The framework of an invention is akin to the hypothesis which serves the scientific investigator in his search for significant facts, and the inventor as well as the scientist may need to try several "hunches" before he finds one that will work.

Stages in creative thought. In the absence of any exact knowledge of the process by which great discoveries and inventions are achieved, there is considerable interest in a suggestion made by several writers who have given much

thought to the matter (*12*, *17*). They divide the whole process into four stages, as follows:

1. Preparation. The problem is examined on all sides, and material is brought together, but a solution cannot be found.
2. Incubation. No serious attention is given to the problem during this interval.
3. Illumination—a flash, a "click," an "Aha! experience."
4. Verification or elaboration.

According to the testimony of many inventors (*13*), the stage of preparation may be long drawn out and include several steps. First, a need or problem is observed and analyzed, then all available information is assembled from memory and from reading—assembled and thoroughly digested—and attempts at a solution are made, criticized and rejected. All this labor, though necessary, is only preliminary to the birth of the new idea which comes without warning on awaking from a good sleep, or while daydreaming, attending a concert or taking a bath—in circumstances that vary from one inventor to another, but not, as they agree, during the anxious search for the new idea.

What can be taking place during the incubation period? No work is consciously being done on the problem, and yet after this interval the solution occurs in a flash. It has been inferred that unconscious work has been going on; but this conclusion is far from sure, for the same possibility is present here as in the case of the forgotten name (p. 350). In the preparatory period the necessary data have been assembled along with much irrelevant material which is an interference as long as it possesses "recency value." When this recency value has evaporated with the lapse of time, and when the individual makes a fresh attack, the whole matter is clear. This theory is at least as probable as the theory of subconscious work.

The four-stage scheme is a little too neat to apply truly to all instances of creative thinking. Certainly the process always starts with preparation and ends with verification or elaboration, but incubation and illumination may overlap, insight being obtained gradually or step by step (p. 531).

Some problems, of course, are solved in a single period of continuous thought, though with the usual back-and-forth, trial and error pattern of exploration. Regarding illumination, it is not true that the whole solution comes in a flash. What comes instantaneously is a promising lead which grips the inventor and holds him to an immediate follow-up of the most intense kind. This period of absorbed thought may last many minutes at least (*11*).

During incubation the problem is not always entirely out of mind. It is likely to come up from time to time and to get a little thought but without the emergence of any promising lead. Such is the testimony of pictorial artists and of lyric poets who have been personally interviewed (*9, 10*). Statements like these are typical:

> I often carry an idea around for several weeks before I make a picture. I got ideas last summer to do now. The ideas recur from time to time while I am occupied with other things.
>
> I have an idea for a poem in the back of my mind for a long time, sometimes a week or two. I don't think constantly about it, but it keeps coming back.

The process by which Coleridge created the *Ancient Mariner* has been made the subject of intensive research (7), and something resembling these four stages can be recognized. An omnivorous reader with a retentive memory, Coleridge had taken special interest in narratives of sea voyages. His plans at the time contemplated much more ambitious poetical works than the *Mariner* or than anything he ever produced. But while awaiting the development of these plans, he took a hiking tour with Wordsworth and the two between them hit upon the simple framework of the *Mariner* story, which Coleridge then filled in, drawing upon his previous accumulation of sea images.

The social factor in invention. To what extent does the process of invention occur within the individual inventor, and to what extent is it a social process in which the inventor participates? Under present-day conditions of industry, inventors are often brought together in large research organi-

zations and produce by teamwork. So much is demanded in the way of scientific background no less than of material resources that the lone worker is at a disadvantage, though many inventive individuals are lone workers by preference. But even the lone worker does not work entirely alone. He has his books and journals in which the work of his predecessors and contemporaries is brought before him. The problems which he would like to solve have grown out of preceding work and out of the needs of the social group. The rewards of fame and fortune which may spur him on are social rewards. In his lonely workshop or studio he is really participating in group activity. Given a common background and the same problems pressing for solution it is not strange that two or more individuals should arrive at the same invention or discovery independently and almost simultaneously, as has happened again and again in a large way, and as happens all the time in a smaller way. Photography was invented twice in 1839, the telegraph three times in 1837, the telephone twice in 1876, the phonograph twice in 1877. Such coincidences could not occur so often if the social factor in invention were not important (*8*). If the social factor were everything, however, coincident inventions would be the rule. All investigators working on the same problem at the same time would be bound to produce the same result. Clearly the part of the whole inventive process that occurs within the individual is crucial. Clearly, too, there are large individual differences in ability to appropriate the available data, to create the ideal framework and to fit the selected data into the framework.

Schools of art. The history of any art reveals the social factor very clearly. Creative artists are commonly found in schools or movements. Each school has a fundamental idea which it exploits, and the members of the school are characterized by loyalty to that idea. In the early days of Wagnerian opera one scarcely thought it decent to enjoy both Wagner and the Italians. It was like trying to be a revolutionary and a conservative alike. With the passage of time the antagonism has died down and both forms of opera are

enjoyed by the same music-lovers and considered worthy forms of art. This calming of the waters was due largely no doubt to the fact that Wagner had no great successors to develop his idea and carry it further. If loyalty, *esprit de corps* and similar social factors were the whole story of productive schools, each artist would be content to go on imitating the master, instead of striving each to make his own originality count. Each strives, within the general frame-

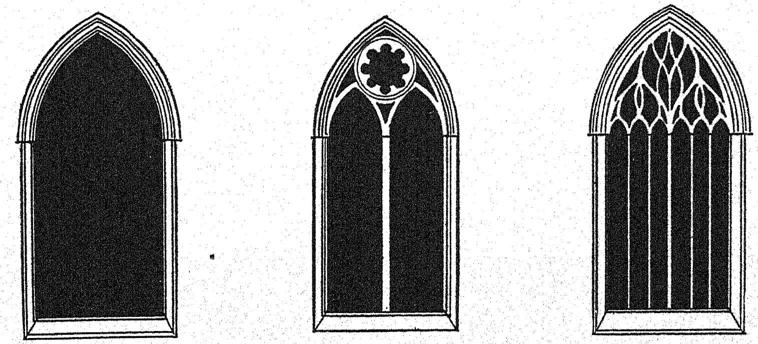

FIG. 109.—The Gothic window in earlier and later stages of its development.

work of the school idea, to produce something new. The result is, either to push the idea to an extreme, or to work it out into ever more complicated forms. In either case the school reaches its limit and gives way to some new school with a new framework to be filled out and elaborated. Thus the Gothic architecture, after developing through a period of several hundred years from simple to more and more elaborate forms, gave way suddenly to the Renaissance style; and thus polyphonic music after reaching its climax in Bach gave way to the symphonic music which is still dominant.

Schools of psychology. The case is about the same with the schools which are prominent today in our science. The psychoanalytic school, of which mention has been made, is concerned primarily with the individual's difficulties of adjustment to life, and is exploiting the idea of repressed wishes

and conflict of motives. Behaviorism as a school is exploiting the idea of objective data. It limits its observations to the visible actions of the individual in the environment and hopes thus to bring psychology more closely into line with biology, chemistry and physics. It declines to take the individual's self-observation or his feelings and experiences as furnishing anything deserving of scientific study. The school of Gestalt psychology or configurationism is exploiting an idea which may be conveyed by the word *pattern*, a word which has been much used in our discussions. This school holds that the individual's process of learning, of perceiving, of thinking, of acting, is always a working from the whole to the parts and not a building of parts together to make a whole. The purposivist school emphasizes the importance of striving and goal-seeking, and the personalist group insists that the individual must always be seen as a whole. All these guiding ideas, and others as well, have been found profitable. The active members of any school are animated largely by motives of personal loyalty to one another and of rivalry toward other schools. These social (rather than scientific) motives lead them to push their own ideas to the limit and to belittle the ideas of other schools, but there is no reason why the outsider should not find value for himself in the work of all the schools (*4*, *6*, *18*).

MANAGEMENT OF THINKING AND INVENTION

This problem could be envisaged either as the problem of society or as the problem of each individual who aspires to do any original thinking or inventing. Since individuals differ considerably in their creative abilities, it is to the advantage of society to discover the most capable individuals and to get as much as possible out of them. They should have opportunity and they should have the stimulus of responsibility. But let us ask what the individual can do for himself in the way of management for creative thought.

Something can be learned from our discussion of the "stages" of creative thought. In order to do effective rea-

soning or imagining the individual needs a good general background, or stock of principles applicable to the field to be cultivated, and a thorough acquaintance with each particular problem that he hopes to solve. He must have the data of the problem at his finger tips—or, more literally, in his memory traces—so that they will be recalled instantly when he needs them. As part of his preparation, too, he should have a try at solving the problem before laying it aside. Possibly he can reach a satisfactory solution at once. But if not, the part of wisdom is to drop the problem for the time and not worry about it any longer. It will recur to his mind at intervals and on some one of these occasions it may reveal a promising lead. Then the part of wisdom is to drop everything else and allow no interruptions till the lead is explored. Finally, anyone who undertakes a large-scale invention or work of art finds by bitter experience that the stage of elaboration lasts a long time, involves much hard work and demands the co-operation of critics and fellow inventors.

Obstacles to clear thought and fertile imagination. As far as straight thinking is concerned, the most obvious obstacle is emotional bias. Anyone's thinking on broad social and economic problems is likely to be warped by his own personal interests as he sees them. Wishful thinking is likely to occur on any topic that touches the thinker's hopes or fears, and his conclusion will often be wide of the mark. But how can wishful thinking be avoided? How can emotional bias possibly be excluded from one's thinking? It is necessary to arouse a contrary motive, like anticipation of the consequences of false reasoning. At a fork in the road where a wrong decision will result in wandering far from the destination, two fellow travelers might get into a dispute and so develop for the moment opposite emotional biases. But if they think ahead to the consequences of a wrong decision, they will probably agree to end their debate and approach the problem calmly. There is such a thing, too, as forming a habit of logical thinking and of being willing to entertain

any hypothesis, no matter how objectionable it may seem, long enough to think out its implications.

Fixed assumptions, whether due to emotional bias or to first impressions, often block the thinker's progress. They prevent him from seeing even quite obvious leads. It is they, more than anything else, that prevent him from solving his problem at once and make it necessary to drop the matter till he can look at the problem afresh. A good rule is to take time out for questioning your assumptions and formulating alternative possibilities.

Egocentric concepts, as opposed to those that are objective, are a great handicap, whether the problem is concerned with people or things. Egocentrically, we see a person only in his relations to us; objectively, we consider his own desires and his relations with other people, and have a much better basis for judging what he will do in a given situation. Egocentrically, we know a thing only as it has affected our personal interests; objectively, we know the thing in its cause-effect relations with other things and can judge how it will behave in a novel situation. Other people are much more interesting than oneself alone; and though the world of things may not be more interesting than the world of people, it is more interesting than one's own single personality and private concerns. The objective view is in the long run both more interesting and more practical.

The magic of words, with their ambiguity and misleading atmosphere, is a source of foggy thinking and often a means employed for befogging thought on controversial matters. A neat phrase or slogan will prevent many people from seeing the facts as they could and would if left to themselves (*16*).

Thinking power. Is it possible to offer any suggestions for increasing one's power of reasoning or of imagination? In a general way, what is needed in either case is a combination of freedom and control. Without freedom one stays in the rut and reaches no new insight or invention, but without control one wanders around and gets nowhere.

A practical question is whether the ability to reason or

invent responds to training and whether it can be transferred from a course in mathematics, for instance, and applied in a very different field. The answer is partly negative. Reasoning consists in seeing implications and therefore depends on acquaintance with the field in which the implications are to be seen. No amount of mathematical reasoning will guarantee ability to reason well in law. One must have a foundation of legal knowledge. On the positive side, courses in mathematics enable some students to get over their natural distaste for intense concentrated thinking. They find it is not necessarily fatal and may even grow to like it. They learn the importance of viewing a problem from different angles, and the necessity at crucial moments of keeping a certain combination of data clearly and steadily before them until they see the implications. In other subjects as well it is possible for the student to build up an adjustment for intense mental activity and to discover certain principles of good management that work well in his case—and then to carry over some of this adjustment and some of these principles into his life work.

Summary of the chapter. The beginnings of imagination are seen in the child's play, especially in his make-believe and story-telling. The motivation of play goes back in part to the primary needs and unlearned motives but in large measure it grows out of the play situation. The mastery motive is active in many forms of play and also in daydreaming. Dreams of the night are often wish-fulfilling but they consist largely in free play of imagination. In contrast to autistic and wishful thinking, controlled imagination undertakes to meet external criticism and to produce something that will prove of value; yet, for all the control, the inventor needs to preserve something like the free imagination of play. A work of art may appeal to various human motives; it always sets a problem and demands imaginative activity on the enjoyer's part. An inventor, poet, artist or scientific thinker, after intensive preparation for a given piece of work, often has to drop the matter and let it "incubate" till some fortunate moment brings illumination. This experience of numerous creative

thinkers contains some suggestions for those who would follow in their footsteps.

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Chapter XVIII

Personal Applications

HAVING gained a comprehensive though rather hasty view of the field of psychology, the reader may well pause a moment before closing the book and ask how his psychological knowledge can serve him in meeting his personal problems. Quite a number of practical hints have emerged already from the consideration of the different topics—hints on judging and improving personality, on efficient management of learning and remembering, on motivation and morale, on training in observation, on conditions favoring clear thinking and fertile imagination. Instead of assembling and reviewing these various suggestions we may raise the more general question, how the psychological point of view confers any advantage in managing one's life as a whole. After the numerous details have faded from memory, will there still remain a saner, more discerning outlook on life? It seems quite possible. The reader has been looking at life from the psychologist's standpoint, and this point of view will remain with him to some extent. It is at least one good point of view from which to see oneself as well as other people.

The psychological point of view. The psychologist tries to observe people's behavior calmly and objectively. He tries to take this attitude toward his own desires and accomplishments, but expects more enlightenment on the whole from a study of other people, partly because he can be more objective in viewing them and partly to avoid overloading his psychology with his own peculiarities. That individuals differ is constantly borne in upon him. He likes to compare one

individual with another. But if every person were absolutely unique, little could be learned from the comparison and there would be no science of psychology.

Individuals, while differing in every way, are after all fundamentally alike. They differ in degree rather than in kind. They meet similar problems and their resources for handling their problems are basically the same. It is really a great advantage to the individual who is having a hard struggle with some problem to know that other people are having the same difficulties. The psychological adviser, from his knowledge of many people, can often reassure the individual by showing him that he is not so peculiar as he imagines.

The best way to "see ourselves as others see us" is probably to see ourselves as we see others. What impression do we get of another person when he behaves as we do in a given situation? Suppose I am inclined to be shy in company, my tendency being to watch the others rather than put myself forward. Now do I know anyone else who behaves in the same way, and how do I interpret his behavior? Trying to look at myself from this angle will lead to a better understanding both of myself and of the other person.

From the psychological point of view, the human being is a "social animal." He is a biological organism dealing with an environment that is largely social. There is some danger here of taking a one-sided view. When we become greatly interested in social behavior we are apt to think that man's being a biological organism is of little consequence, the important human fact being his membership in a group of people. When he talks he is of course using his vocal organs, but the important fact is that he is informing, or questioning, or commanding, or imploring some other person. Well and good—but the state of his digestion, of his glands, and of his organism in general may make the difference between effective and ineffective communication with his fellows. The ideal person is a healthy animal participating intelligently and wholeheartedly in the best activities the environment has to offer.

Continuity of life, from before birth up through the de-

velopmental period and on through maturity, is another fact that the psychologist does not overlook. The young adult is apt to feel, "I was only a kid a few years ago. I'm altogether different now." But it is neither possible nor desirable for him to throw away his childhood. He has to build on the foundation already laid down. He can drop certain forms of behavior, he can "reform," he can engage in new lines of activity and develop his interests and abilities in new directions, but the core of his personality remains the same. He himself, as he is from his past, is a powerful factor in what he shall become.

From the psychological point of view all behavior and conscious experience are effects that have their causes. This fundamental article in the psychologist's creed seems trite enough—for every event must have its cause—but the everyday view is really quite different. "I just happened to think of something," we say, or "I just happen to dislike that person," as if such psychological events had no causes. When a person's behavior is objectionable to us, we speak as if he were perverse and that were the end of the matter. The psychologist asks after the causes of the perversity—the motives, the training, the background in the individual's heredity and environment. The psychologist cannot always unravel the tangle of causes, but his creed implies a tolerant and hopeful attitude. So far as he can discover the laws of human nature, he has hope of helping the individual and eventually of bettering the developmental conditions of life so that human behavior can be stepped up to a higher level.

ADJUSTMENT AND MALADJUSTMENT

If an individual is participating intelligently and wholeheartedly in what is going on in his environment, we have no hesitation in calling him well adjusted. If his participation, while wholehearted enough, is not intelligent, his adjustment lacks something on the side of observation and knowledge. If he is taking part intelligently enough but not happily, his adjustment lacks something on the side of emo-

tion and interest. Sometimes the thing to do is to get out of that environment into another more suited to one's intelligence and interests, but often the best solution lies in readjusting the individual.

But how is it possible, according to our general conception of set or adjustment, for any maladjustment to arise? Is not the individual set for the situation, after he has explored it, and is he not set for a goal? Yes, but we have never claimed infallibility for him. In exploring a new situation, his observations may be superficial. Too little analysis, too much assimilation of the new to the old may occur. For one reason or another the situation is misunderstood and bungled. Or, the individual sees the facts clearly enough but has no liking for the part he is expected to play. Or again, he is torn by a conflict of desires. He wants to do all that is expected of him, but finds it impossible to please everybody. He may feel very badly about it, and have a disturbing sense of guilt over what he is doing or failing to do.

A special course in abnormal psychology, rather than a few pages here, would be required for opening up the large subject of the neuroses and psychoses with their manifold manifestations. Some persons are beset with fears and anxieties which they themselves admit are foolish but which they cannot overcome. Some persons are haunted by strange ideas which they cannot shake off. Some have an unaccountable lack of energy and self-confidence. Some have physical symptoms like loss of appetite and apparent loss of muscular power or of sensation. So far we have "neurotic" symptoms. Still more serious are the psychoses or insanities, showing as extreme excitement or depression, or as withdrawal from the environment to such an extent as to be incapable of effective contacts with other people, or as terrible suspicion coupled with an overweening assertion of superiority.

The causes of these abnormal conditions are by no means clear. Quite possibly, the body chemistry is involved. The belief of many psychiatrists, with regard to the neuroses at least, is that they are forms of maladjustment different in

degree rather than in kind from the minor maladjustments of which everyone has some small share, maladjustments due largely to bias and conflict of motives.

Psychiatrists have devoted a great deal of thought to the problem of how these neuroses originate, and have formulated a number of theories contradicting one another except on the point that the neuroses are due to conflict of motives or to frustration of desires. To evaluate these theories would obviously be too great a task for us here. Just a little may be said. It may be remembered that we classified the primitive motives, or most of them, under the head of three demands of the individual: the demands for security, for pleasure, and for achievement. According to Freud's theory maladjustments result from frustration of the demand for pleasure, or as he put it to frustration of the more childish forms of sex desire which he believed to be present quite actively even in the young child. Speaking more broadly we may say that the young child finds sources of pleasure in nursing, in his processes of elimination, and in cuddling and other loving behavior of the mother. In being weaned, in having to restrain his processes of elimination, and in being deprived of some of the devotion of the mother, he finds his desire for unlimited pleasure blocked and is thrown into a conflict situation which contains, according to Freud, the germs of all life's future maladjustments.

Adler (*1*) set up a different theory. The child's fundamental desire is conceived to be a demand for superiority and for overcoming the inferiority inherent in his status as a little child. His demand for superiority is subject to continual frustration and makes it difficult for him to adopt the give-and-take of a socialized human being. Unless the socializing process is tactfully managed by the parents, the child devises for himself a peculiar "style of life" which gives him some sense of superiority though it is unsuited for real achievement. According to Adler, then, maladjustment arises from frustration of the individual's demand for achievement.

Others of the general psychoanalytic group (p. 395) lay most stress on the demand for security. There are many

ways of making the little child feel insecure. He is weak and helpless if left to himself. He is perhaps warned too much against the common dangers of life. If his mother takes a brief vacation from home duties, he is apt to feel deserted. If he is scolded, he feels deprived of affection and, momentarily at least, cast adrift in a hostile world. The child does not always outgrow this feeling of insecurity, and it may be accentuated in the adult struggle for existence and social recognition.

Without undertaking the almost hopeless task of deciding between these theories as explanations of the neuroses, we may at least admit that every one of them has pointed out certain difficulties in the way of an easy adjustment to life's conditions. As we advance from infancy toward maturity, pleasures of the more childish sort must be relinquished, increased responsibility and decreased protection must be accepted as a matter of course, and higher and higher standards of achievement must be met. Every such change costs effort, calls for readjustment and opens the door to maladjustment.

Ways of helping maladjusted individuals. A child's maladjustments are handled quite directly, though not always successfully. A counselor from outside the home (or schoolroom) secures the child's confidence, and enlists his co-operation in an effort to see what the trouble is, what the conflicting demands are that have not been properly adjusted. If the problem arises in the home, or leads back into the home, as most problems of young children do, the co-operation of the parents must be secured, and often their behavior toward the child needs to be changed. The general plan is to lead the parties to see the situation clearly and to work out a solution in the light of the facts. "Facing the facts" is the main principle (p. 190).

The maladjustments of an adult cannot be handled so directly, because their sources may lie far back in the individual's experience and may have been forgotten. An irrational fear often dates back to childhood. If old memories can be revived (p. 351), so that the original facts can now be

faced squarely, the individual may throw off the childish fear and regain his self-confidence. But there is no sure cure for all cases. Strange as it may seem, the individual may cling to his fear or other maladjustment, in spite of its inconvenience, because it has come to mean something for his personality. He feels lost without it.

Anyone who is poorly adjusted to a life situation may find a useful suggestion in the proverb that "two heads are better than one." What he needs is not advice altogether. He needs the chance to use his own head in explaining the problem to an understanding friend, and if the friend does not understand the whole difficulty instantly, so much the better. The person who is in difficulty will understand it better himself after making it plain to his friend. Silent brooding over a troublesome personal matter is almost sure to give a distorted view. Minor maladjustments usually clear up in a confidential talk with a friend, without calling on the professional counselor. More difficult problems, however, do require the assistance of the expert. "Giving advice" is not exactly what the counselor does, for he is careful to leave the individual a large share in solving his own problem and planning his own further course of action. The counselor, from his experience with similar problems, can see the ins and outs of the present problem better than anyone who is new to this type of difficulty. The counselor sees the situation objectively while the individual personally concerned is likely to be biased and emotional. When the emotional disturbance cuts deeply into the personality and upsets the individual's life with nameless fears and fixed ideas, the expert with experience in this type of cases is the psychiatrist.

The various methods of treating the neuroses may be examined with quite a modest purpose. We cannot attempt to decide which of the various rival methods is the best or only true method, but we may obtain a little information on ways in which maladjustment can be overcome.

There are two main steps in psychotherapy, as the treatment of maladjustments is called. The first step is to find the source of the trouble and to get the individual to face the

facts. The second step is to induce him to advance hopefully toward full health and well-adjusted living. There are several methods of psychotherapy.

Suggestion and hypnosis. A "suggestion," in the sense here intended, is an idea or plan of action adopted by the individual without calling it in question.

One person is more suggestible than another, and the same person is more suggestible at certain times, or in certain states, than otherwise. The most suggestible state is hypnosis, a passive and sleeplike state that is nevertheless attentive and concentrated. The hypnotized subject, it appears, is awake simply to what the hypnotizer suggests, and inaccessible to other stimuli. His field of activity is narrowed down almost to a point (*3*).

Hypnosis may be deep or shallow. Comparatively few persons can be deeply hypnotized, but many can be put into a mild state of suggestibility. Where the waking person is alert, suspicious and assertive, the hypnotized subject is passive and submissive. The subject's co-operation is necessary, as a rule, for inducing any hypnotic state.

The means of inducing hypnosis are many and varied, but they all consist in gently wafting aside all extraneous thoughts and interests, and getting the subject into a quiet, receptive state with all his attention focused on the operator.

With the subject in this state, the operator's suggestions are accepted with less resistance than in the waking state. In deep hypnosis, gross illusions and hallucinations can be produced. The operator hands the subject a bottle of ammonia, assuring him it is the perfume of roses, and the subject takes a deep whiff with every sign of enjoyment.

In mild hypnosis, these very striking phenomena are not obtained, but suggestions of curative value may be accepted with useful results. Hypnosis is employed in both the main steps of psychotherapy: to revive a forgotten memory which reveals the origin of the trouble, and to fill the subject with the idea that the old trouble is of no consequence and that he is going to be well.

A young woman who was subject to serious hysterical at-

tacks was able under hypnosis to remember how they had originated. While watching a fire she had been terrified to see children jumping out of the windows. She was induced to remember also that these children had been caught in the firemen's net and saved from harm. So the memory was relieved of most of its terror, and the suggestion was then given that this experience would not trouble her any more. This treatment was successful in putting a stop to the hysterical attacks. While removing a distressing symptom, however, suggestion may fail to reach an underlying maladjustment, and for that reason many psychotherapists regard hypnotism as of little value. They believe that the subject must do more than accept suggestions and that he must take an active part in working out a good adjustment to his life problems.

Psychoanalysis. In the strict sense, psychoanalysis is Freud's theory and practice and does not include any of the similar theories and methods that have been developed by his successors. In Freud's view the only way to treat a neurotic individual is to get back to the origin of the trouble in childhood. Instead of hypnotizing the patient, Freud had him recline and relax and become as uncritical as possible while letting thoughts and memories come by "free association." The association or recall process was controlled to this extent, that the patient must not let his mind wander to trivialities but should be looking for memories of personal significance. Freud usually asked the patient first to relate a dream of the previous night, and then the dream was "analyzed" by free association. Taking each item in the dream as a starting point, the patient let his mind play freely about that item so as to find what it suggested in the way of personally significant material. In this way, often after many visits, memories of childhood came up, revealing such attitudes as desire for the mother and opposition to the father, in a male patient. By dwelling long on these memory fragments, the patient came to revive some of the emotional attitude of childhood. The child's attitude toward the father—an attitude partly of love and dependence, partly of resentment and rebellion against authority—on being revived, attached itself to the

psychoanalyst as the most available present substitute for the father. When this "transference" had been secured, the next stage of the treatment consisted in re-education of the patient. Under the guidance of the psychoanalyst he practiced for many weeks in handling the difficulties of his present life, being gradually weaned from his childish dependence on the psychoanalyst and becoming more and more capable of managing his own affairs.

Psychoanalytic treatment takes a long time and should not be begun unless the patient is prepared to see it through to the finish, for if dropped in mid-course it leaves the patient worse off than before. It should not be undertaken except by one whose difficulties in life are quite serious. It is not regarded, even by the psychoanalysts, as providing a "cure" in the usual medical sense, but it does enable many much-disturbed persons to "carry on" better than they could before the treatment.

What interests us here, in regard to psychoanalysis, is the benefit obtained from getting back to the source of a difficulty. An attitude that disturbs a person's life may have arisen in some situation of childhood which has little importance from the adult's point of view. Once he sees and "feels in his bones" that this attitude is a mere carry-over from childhood, he can treat it lightly. An adult's terrible fear of running water disappeared when it was traced back to a childhood experience of terror combined with guilt. Even without being able to trace back all of our irrational fears and antipathies to specific events, we can rest assured that they arose by some kind of "conditioning" and that they have no real importance for our adult lives.

Freud has many partial followers who owe much to his psychological approach to the problems of neurosis, and to his emphasis on conflict of motives and on the "unconscious" or unanalyzed character of many motives, but who do not accept the whole of his complicated theory nor follow his methods in detail. Adler had considerable success, at least with young persons suffering from minor maladjustments, by use of much simpler and quicker methods. In a few inter-

views he could discern the subject's "style of life," adopted in early childhood and adhered to throughout life. He led the subject to see his "style" and to adopt useful ways of reaching his goal instead of the inefficient and troublesome ways carried along from childhood (*1*).

Other partial followers of Freud believe that less depends on going back to childhood and finding the infantile origin of the maladjustment than on tracing out its consequences in the adult's present ways of handling his problems. The neurotic person not only suffers from his maladjustment but he uses it; it is his way of getting something he cherishes. To take a simple example: the person who has a headache whenever a desirable group activity is in prospect puts other people out as well as himself and thus achieves a measure of dominance—or he may have a sense of social insecurity that makes him dread a large party. The ramifications of these motives are often very surprising (7).

Still other practitioners are more akin to the "faith healers" who dispense with any scientific background and still have some success. There is even some psychological justification for "letting the dead past bury its dead" and facing confidently toward the future. Many scientific practitioners agree that the battle is half won when the patient fully believes he is going to be cured. Where his goal has been that of an invalid, it is now health and a normal social life. Even though this attitude is not a cure-all, it is an asset.

PERSONAL PROBLEMS

Aside from the obviously important matter of general health most personal problems are concerned with one's relations to one's fellows—"fellows" including parents, friends and associates, wife or husband and children.

"How to get along with one's fellows" is the basic problem—how to live the life of a socialized human being, and enjoy it. The infant encounters this problem; if he finds a good solution he makes life relatively easy for his later self. If he doesn't get beyond the purely selfish attitude of using

other people as tools for ministering to his own pleasure, he becomes a social problem more than a social being. It would be too much to expect the child, or anyone for that matter, to go to the other extreme and adopt an entirely unselfish, altruistic attitude, seeking only to be of service to other people. Nor is such an attitude socially desirable. It is undesirable in the child's mother because it spoils the child. Give-and-take, participation, is the only genuinely social principle.

A social being is one who takes part in group activity. He likes being a member of a team. Now good teamwork is neither selfish nor altruistic for the individual members. Each member is not working for himself, nor is he working to serve his fellow-members. He is working for the team as a whole. He has not left behind such individualistic motives as the desire to dominate, but he adopts the team as his larger self. He boasts of the achievements of the team rather than of his individual prowess. Man's capacity for engaging in teamwork is perhaps the most hopeful sign for the future of the race. It does create problems, indeed, for the rivalry between groups—nations especially—may become exceedingly fierce and destructive. But in many spheres, such as sport, science and art, experience shows that it is possible for group rivalry to have results that are mainly constructive rather than destructive. Problems of social psychology emerge here which lie beyond the scope of this book.

Our question is whether the ideal of teamwork can be applied in such small but important groups as a pair of chums or a married couple. It is easy to see that no such group can be a success if each member is simply using the other as a means of getting pleasure—or security or achievement—for himself. In many such pairs, married couples especially, a certain amount of disturbing rivalry develops, each member seeking "unconsciously" to dominate the other. A young man and woman on first being attracted to each other delight to find themselves alike in all possible respects, but as time goes on they tend to assert their own individualities, as is quite natural. A knowledge of the psychology of motiva-

tion should enable each member to tolerate, or better to welcome, some self-assertion on the other's part. There are some sly, though very polite, ways of dominating that are rather hard to bear. The husband's superior attitude may manifest itself in always treating his wife's remarks and suggestions as unimportant, or as always needing some correction or improvement from him. The wife may never allow her husband to have the last word. Both husband and wife may lower themselves to become rivals for a child's affection. We might suppose that wedded bliss would be poisoned mostly by a lack of satisfactory sexual relations, as is indeed sometimes the case from various causes, including ignorance of what to expect in married life; but unhappiness results more often from conflicting tendencies to dominate. There is no doubt that happy sex activity, not excessive in amount, keeps the warmth alive; but mutual respect and admiration need also to be kept alive. Everyone can stand a little praise now and then, though some people seem to think it very dangerous for their best friends; never expressing appreciation, they confine their comments to imperfections noted in their friends. Life with such people, exemplary though they may be in other respects, sooner or later loses its zest (*4*).

One difficulty with the married couple as a team is the lack, sometimes, of any goal for which they are working as a team. If they run a farm or business together or have a family to bring up, they have a goal; but many young couples seem to have no goal in sight better than "keeping up with the Joneses." For the best teamwork a goal is certainly necessary, and it is hard to suggest any goal for many married couples. If they recognize the need, however, their ingenuity will often find a way.

In the absence of "trial marriage" which is scarcely practicable, some valuable practice for meeting the social problems of marriage can be obtained from friendships. One can practice the arts of presenting one's own views tactfully, of combating another's view without giving offense, of engaging in debate without losing one's temper. The main thing is to have, and show, some respect for the other fellow's

opinion while still making sure that the truth as one sees it gets a hearing (*5*, *8*).

Vocation and avocation. The years spent in education, while pleasant at the time, should also prepare for life; and when we think of life we should think of play as well as work. In fact an education may prepare for play more directly than it does for any specific line of work. Take reading, for example. If we have learned to read easily and well, and if our education has given us a start in reading along some interesting line, our resources for enjoyment are greatly enriched. Why not consider this possibility in the selection of college courses? It might be worth considering in the selection of a "major," for one needs to get into a subject some little distance in order to follow it up easily as one would wish to do in leisure time. Sports and other extracurricular activities are also worthy of consideration as a preparation for life. A hobby lying wholly outside the field of college activities may be worth keeping up for use later. Or one's later recreation may be found in social activities such as clubs, politics or community life. The play life cannot be rigidly planned in advance, and yet some planning is possible in view of one's probable lifework.

So far as planning is possible, vocation and recreation may well be considered together, and the recreation may be chosen to compensate for the limitations of the vocation. If the vocation is going to be sedentary, some form of muscular outdoor recreation should be in prospect. If the vocation is likely to be a routine affair calling for submissiveness rather than mastery and achievement, recreation may be made to afford an outlet for these blocked motives.

When it comes to the choice of a vocation, the problem is so broad and complicated that a thoroughly rational solution would seem almost impossible. The United States Census lists about 25,000 different occupations, and many of these, like the learned professions, include a great variety of particular occupations. Think of the medical profession, for example!

Suppose a young man or woman should wish to dis

cover which one of all these occupations was most suited to his interests and capacity. Probably the logical first step would be to go to a vocational counselor and have an appraisal made of his present abilities and interests. His intelligence score or his score in more special abilities might quickly rule out a large number of occupations, some as demanding too much intellectual energy, some as demanding too little. Still there would be a large number of alternatives to choose from. An "interest blank" would throw some light on the problem, for it is found that successful men or women in one occupation have different interests, not entirely vocational interests, from those in some other occupations. The interests of engineers, physicians and journalists differ considerably. Though college freshmen are likely to change their interests somewhat within the next few years, some freshmen would find from the interest blank that their present interests, at least, were quite out of line with those common in the occupation to which they are now inclined. Some would find their interests closely in line with an occupation they had never considered. So the interests as well as the tested abilities will narrow down the list of alternatives, and the counselor may help to narrow it down still more, though he will seldom take the responsibility of making a definite positive recommendation. The individual should eventually choose for himself.

This matter of choosing a vocation may well be in the back of the student's mind for years. One phase of education, formal or informal, should consist in exploring the world's work and learning something about the actual operations and responsibilities demanded of individuals in a number of occupations. Looking at an occupation from the outside, one usually gets only the vaguest impression of what the workers in that line actually do. A young man thought he would like to be a civil engineer. Tests showed him to have only moderate intelligence and very little mathematical ability. He was then asked what there was about civil engineering that appealed to him, and he answered that it was attractive because it was outdoor work. When told of the

office work and the mathematics, he decided that was not at all what he wanted. Landscape gardening was suggested, and he agreed that it was more in the line of his interests.

A survey of occupations should of course include a study of the labor market, actual and prospective. Now that a larger and larger proportion of young people are continuing their education up through high school and college, there is a tendency for a great surplus of candidates to aim at the occupations associated with higher education, while the professions themselves are fighting against becoming over-crowded. If we believe it desirable for a large share of the population to have a college education, we must accept the corollary that many college graduates will find their work outside of the recognized professions. We shall have educated carpenters and department store saleswomen. Why not? We must ignore tradition and recognize that the dignity of an occupation depends on the personal worth of its personnel (*2*, *6*).

In saying farewell to the patient reader, the author ventures to express the hope that this book will be merely an introduction to reading and thought on the subject of psychology. Something was said at the beginning of the chapter about this book's being "comprehensive." It is so in a way, since it has touched on the main topics, but in many instances its touch has been feather-light. Imagine all the interesting material that lies beneath those light touches on animal behavior, child development, abnormal psychology! The study of individual differences, with its tests, statistics and correlational analysis, is one of the active branches. Experimental psychology is penetrating more and more deeply into the processes that we have considered, learning, thinking, observation and emotion. Physiological psychology is making progress in discovering the organism's mechanisms for carrying out these processes. Social psychology is obviously a very broad and fertile field, extending as it does from the child's first personal contacts to the social behavior of the adult, and from the behavior of small friendly groups to the

activities of large masses and organized groups of men in their political and economic enterprises. And then we have the applications of psychology which are varied and increasingly important—applications to clinical practice, to education, to business and industry, to law and criminology. Each of these applications demands specific research and runs out into many branches.

Psychology is still a young science; its achievements cannot compare with those of older sciences like physics, chemistry and biology; but it is in a flourishing state and there is no reason, in all logic, why this science and its applications to human engineering should not be more and more significant for human welfare as the years and decades go by. This is not a plea to all students who feel an interest in psychology, urging them to make it their lifework; it is a cordial invitation, however, to pursue the subject further as circumstances permit.

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Questions and Exercises

These questions are designed to assist the student in understanding the text and in putting together material from different parts of the text.[1] One good general exercise consists in working out a logical outline of each chapter.

CHAPTER I. The Aim and Method of Psychology

1. "What I hope to get out of psychology." State what seem to be the values to be expected from this study.
2. Why cannot a hypothesis be absolutely proved? What good is it then?
3. Some people think it is terrible for the psychologist to experiment on human beings, making them his "guinea pigs." What do you think?
4. How does the use of a large number of subjects in a psychological experiment tend to hold certain factors constant and so bring out the effect of the independent variable?
5. Why is it often necessary for *E* to conceal from *O* the purpose of a psychological experiment?
6. How would you conduct a developmental study of the change of interests in adolescence?
7. What kinds of psychological knowledge can be obtained by use of the case history method?
8. What is meant by saying that *O*'s conscious experience is part of the process of nature?
9. An experiment: Compare the time it takes you to add a column of 8 two-place numbers with the time required to add a similar list of numbers placed in a horizontal row. Note which arrangement was more agreeable. Now show which of your data are introspective and which are behavior data.
10. Analyze the experiments on aviation sickness so as to show the factors held constant, the independent and the dependent variables in each case.

CHAPTER II. The Individual in His Environment

1. Show that a nation interacts with the world outside much as *O* interacts with *W*.
2. Take some simple instance of "dealing with the environment" and trace out the series of events in the individual and in the environment.
3. Bring out the psychological difference between (a) being "forced"

[1] Additional questions and other material for study purposes are to be found in G. Milton Smith's *Workbook in Psychology*, Rev. Ed., N. Y., Holt, 1940.

to do something, and (b) being forcibly prevented from doing something.

4. Give a concrete instance of the practical value of preparatory set, and also of continuing set.

5. Take the word "River" as a starting point and let your thoughts wander freely for a minute. Review and note down the series of thoughts and ask how each was associated with the one that called it up.

6. Of all the experiments described in this chapter, which ones use introspection and which use objective observation?

7. You enter a novel situation, adjust yourself to it and do something with it. Give a concrete example.

8. How long does it take you to read 5 pages of an interesting story (along in the middle of the story)? What is your reading rate, approximately, in words per minute?

9. How did the use of "matched groups" enable an experimenter (p. 49) to hold certain factors constant and so bring out the effect of distraction, his independent variable?

10. Go over a few pages of current advertising material, and note what devices are used to attract and hold attention.

CHAPTER III. Individual Differences in Ability

1. Mention some capacities which you have not developed very far and probably may never develop.

2. What is meant by testing a "fair sample" of the population?

3. Draw diagrams illustrating normal, skew, and bimodal distribution.

4. What is the psychological objection to labeling people as either attractive or unattractive? Discuss.

5. Do we find more positive or more negative correlation between abilities, and what is the inference?

6. Can a "reliable" test have only low "validity"?

7. If we should find a low positive correlation between athletic and scholastic achievement, what could we infer?

8. Explain, with examples, the distinction between specific abilities and group abilities or factors.

9. What is really meant by "verbal ability"?

10. Survey of one's own imagery. Try to call up the images mentioned below, and rate each image on the following scale:

3. . . . image clear, bright, realistic
2. . . . image only moderately bright and realistic
1. . . . image almost devoid of sensory quality
0. . . . no sensory image even when the object is remembered

Call up the visual appearance of: a sunflower, automobile head lights, a large dog, your own signature

Call up the sound of: a church bell, a dog barking, a siren whistle, paper tearing

Call up the feel of: velvet, a lump of ice, lifting a heavy weight, riding in an automobile

Call up the odor of: coffee, camphor, apple, onion

Compare your average rating for each of the four classes.

CHAPTER IV. Intelligence

1. What is meant by an operational definition of intelligence? By a correlational definition?

2. Why should a 10-point rise in an individual's IQ not be taken very seriously, if no more is known about him?

3. Why is the sampling of the intelligence of Scottish children (p. 129) regarded as especially fair?

4. Discuss the advantages and disadvantages of a city environment as a means of stimulating intellectual development.

5. Is it sensible for a mother to coach her child before he is due to take an intelligence test?

6. Compute the IQ of the following children:
   - A. Chronological Age, 4 yrs., 8 mos.; Mental Age, 5 yrs., 6 mos.
   - B. Chronological Age, 7 yrs., 9 mos.; Mental Age, 5 yrs., 6 mos.
   - C. Chronological Age, 10 yrs., 10 mos.; Mental Age 14 yrs., 0 mos.

7. If a child gets an MA of 7 years and 4 months when his CA is just 6 years, what will be his MA at the age of 12 years, provided his IQ remains constant?

8. How can public provision for the feebleminded diminish the number of feebleminded criminals?

9. Give at least two reasons why it is more hazardous to predict academic success in college from the results of an intelligence test, than it is in the elementary school.

10. Discuss this topic: false and exaggerated conceptions and valuations of the IQ.

CHAPTER V. Personality

1. Can you show that a beautiful face is likely to affect the owner's personality?

2. Why is it important to lay your own feelings aside while attempting to understand another person?

3. What personality traits are desirable or undesirable in one who would be an interviewer?

4. What suggestions do you find in this chapter (or elsewhere) that may be helpful in the everyday judging of personality?

5. If you should place a child alone in a room with toys and picture books, and watch him through a one-way screen, what personality traits might he reveal?

6. Summarize the difficulties in the way of obtaining a good measure of personality.

7. Illustrate the difference between self-consistency and trait generality by examples from sports and athletics.

8. Make up a list of 10 questions to use in locating the individual along the dimension of ascendence-submission, or along some other dimension of personality.

9. Rate a large number of your acquaintances in some one trait. Use a separate line (graphic rating scale) for each individual, and then assemble all the ratings on a single line so as to show the distribution of your rat-

ings. What kind of distribution do you get, and does it suggest any criticism of your ratings?

10. Using a profile diagram like that on p. 162, rate one person in several traits, and ask someone who knows this same person to rate him in the same traits. How well do the two (independently produced) profiles of the same person agree with each other?

CHAPTER VI. Physiological and Social Factors in Personality

1. What would you regard as the most probable factors in producing a cheerful disposition?

2. What is the objection to such expressions as "thyroid personality"?

3. Which of the endocrine glands seem to have most to do with the emotions?

4. Show how the principle of resistance to the environment shows up in the development of the individual's personality.

5. Show that there are various forms of competitive behavior.

6. In the case of some one of your acquaintances, consider what different personal roles he plays.

7. What are the promising procedures for increasing an individual's self-confidence?

8. What is meant by "endocrine balance"?

9. How much importance do you attach to the neighborhood and the play group, as compared with the home situation, in the development of personality?

10. Analyze Mark Twain's case history so as to bring out the continuity in his development.

CHAPTER VII. Heredity and Environment—Development

1. From your knowledge of family life, discuss the statement that the same home is not the same environment to all the children in the home.

2. Explain and discuss the statement that the individual makes or selects his own environment, to a large extent, in accordance with his heredity.

3. Discuss the statement: If we know the IQ of both parents we know the child's heredity so far as concerns his intelligence.

4. Why do identical twins teach us more about environment than about heredity?

5. What is the cause of maturation?

6. What makes it difficult to reach a sure answer to the question whether the child really learns to walk?

7. State in words what is shown by the figure on p. 226.

8. Judging from your own experience, how much increase in intelligence occurs during the adolescent period?

9. In what respects are men and women of 50 superior to those of 20?

10. Is it safe for a democracy to act on the assumption that good environment is enough to insure good intelligence and personality?

CHAPTER VIII. The Nervous System

1. How does the synaptic type of connection in the nerve centers make it possible for the individual to act in many different ways?

2. Is the time occupied by a "simple reaction" to sound (p. 30) mostly required for the nerve impulse to traverse the sensory and motor nerves? (Consider the length of those nerves and the speed of nerve conduction.)

3. What is the difference between a strong and a weak contraction of a muscle?

4. Is the gray matter more important than the white?

5. Summarize the evidence in favor of the motor area (or of the visual area).

6. Of what use is the callosum?

7. What functions are tentatively assigned to the two large association areas?

8. If someone told you that the brain "acts as a whole," what would you say to set him straight?

9. Why is it difficult to demonstrate the effects of mental activity on brain structure?

10. Where would you expect the brain or nerve injury to be in each of the following cases?

(a) Blindness of the left half of the normal field of view
(b) Blindness of the right eye
(c) Inability to recognize seen objects
(d) Inability to identify objects on handling them
(e) Inability to recognize familiar spoken words
(f) Inability to move the left hand

CHAPTER IX. Learning

1. List the experiments on animal learning, with a brief statement of what each proves.

2. Give an example of a "higher unit" in talking, in playing the piano or some other instrument, and in driving an automobile.

3. Is the extinction of a conditioned response the same as a forgetting of that response?

4. Why do we see no trial and error in the process of establishing a conditioned response?

5. Discuss the question whether foresight always depends on previous hindsight.

6. What facts suggest the reality of true motor learning?

7. Show that reward and punishment may be important factors in the child's learning of the social code, or in the adult's acquisition of social poise.

8. What causes keep the learner on a plateau, and what causes enable him to rise to a higher level?

9. In what ways do the study habits and methods of the expert differ from those of an average student?

10. A practice experiment. Take several pages of uniform printed matter and mark it off into sections of 15 lines. Take your time for marking every word in the first section that contains the letters *a* and *t*. The two letters need not be adjacent but both must be present somewhere in the same word. Having recorded your time for the first section, do the same thing with the next section and so on for 12 sections. What were you

able to observe, introspectively, of your method of work and of the changes with practice? From the recorded times, plot the learning curve.

CHAPTER X. Memory

1. How can anything once learned ever be forgotten?
2. Show how individual differences in ability to memorize a paragraph may be due to past experience.
3. How does recall play a part in free and controlled association (p. 33)?
4. Point out some resemblances between the process of learning a maze and the process of memorizing a paragraph.
5. Discuss the advantages and disadvantages of cramming.
6. What is your personal reaction to the question of whole vs. part learning?
7. Try the plan of going over a lesson once before retiring at night and reviewing it the next morning. What advantages or disadvantages do you see in this arrangement?
8. Are recall and recognition essentially the same process?
9. How can memory be used in improving one's personality?
10. What is your earliest childhood memory, and how do you know it is a true memory?

CHAPTER XI. Motivation

1. Which of the unlearned motives tend to restrict or inhibit activity?
2. Using anger as an example, bring out the distinction between stimulus, motive and incentive.
3. Take some interest of your own and try to trace it to its sources.
4. Discuss the question whether all motives are derived from a few unlearned motives.
5. Show that a person who does not care to dominate other people may yet have some masterfulness or self-assertion in his attitude and behavior.
6. On a graphic rating scale (p. 146) rate several individuals for the strength of their demands for security, pleasure and achievement.
7. If a person has an unreasonable antipathy to another person, how would you attempt to get him to adopt a more favorable attitude?
8. How would you analyze or explain the sentiment of patriotism? Or of college loyalty?
9. Discuss the statement: "It is the individual that must be satisfied, rather than any specified one of his tendencies."
10. Comment on this piece of advice: "To get action from yourself, find worthy competitors."

CHAPTER XII. Feeling and Emotion

1. Why should a brisk walk dissipate an emotional state? What other indirect means can be used to control or eliminate an emotion?
2. What is the difference, if any, between an emotion and a desire, as emotion is finally described in this chapter?
3. The author speaks of fatigue and drowsiness as emotions. Is he justified in doing so?

4. Rate the annoyances (pp. 415-416) on a scale of 0 to 100, with 100 indicating the greatest possible degree of annoyance.

5. Compare this statement with the James-Lange theory: "Danger is not recognized until the organic state of fear has been aroused."

6. Do the physiological experiments cited in the chapter show that an organic state is not really included in the emotion, and that the set-state formula does not hold good?

7. What emotions are apt to be pleasant, and what is the set or impulse in each of them?

8. Discuss this question: Can we properly speak of one individual as more emotional than another, in general, or must we specify particular emotions?

9. How are fears acquired and overcome?

10. Following Wundt's three-dimensional scheme of feeling, locate each of the following states of feeling:

(a) Waiting for the point of a joke
(b) Just after the point has come out
(c) Waiting for the dentist to pull
(d) Just after he has pulled

CHAPTER XIII. Observation

1. How can we perceive the desires and intentions of other people?

2. What groupings and shifting occur when you look steadily at the color-naming test blank on the Frontispiece of this book?

3. Tabulate the factors of advantage in attention (Chapter II) and in grouping.

4. What part of the cortex is presumably most directly concerned in the grouping of dots and the seeing of figure and ground?

5. How does the shifting that occurs in viewing an ambiguous figure differ from simple shifting of attention?

6. Show some analogy between Weber's law and this fact: The loss of a dollar means more to a poor man than to a rich man.

7. Trial and error perception. Go about the room with eyes closed, and identify objects by touching them with the hands. Note any instances in which the first impression had to be corrected by further exploration.

8. What is the difference between an illusion and a hallucination?

9. Discuss the assimilation of the new to the familiar with examples from the figure on p. 352.

10. Illustrate the statement that people differ in their observations because of difference of interests.

CHAPTER XIV. The Sense of Sight: Visual Sensation and Perception

1. State briefly the function of each of the following structures: the cornea, the lens, the rods, the cones.

2. What are the uses of indirect vision?

3. Count the eye movements of a person who is reading and determine the number of his fixations per line of print.

4. By using the after-image, determine the complementary color for several hues such as purple, orange, yellowish green.

5. How could the red and green used in traffic signals be slightly modified and made distinguishable by the red-green blind individual?

6. Hue matching. In the Frontispiece, the colors on the right side have the same hue (though of different saturation and brightness) as the colors on the left side. Match each numbered hue with a lettered hue, recording the pairs.

7. What confusions would be expected in this test from a red-green blind individual?

8. What is the difference between "picture size" and "object size"?

9. What is the difference between "picture color" and "object color"?

10. Explain what is meant by these indicators of distance: perspective, aerial perspective, covering, shadows.

CHAPTER XV. The Other Senses

1. Show that the muscle sense is much used in getting acquainted with the environment.

2. What senses can furnish information regarding the pull of gravity and the up-down dimension of space?

3. List in tabular form the sensitive cells and accessory apparatus of the senses of sight, hearing, smell, taste, and head rotation.

4. Make a list of all or most of the senses, noting for each the salient sensations and one or two blends.

5. In perceiving the environment, in what ways is the eye superior to the ear and in what ways is the ear superior?

6. In which senses are the stimuli chemical, and in which are they mechanical in nature?

7. Compare the sensory adaptation mentioned in this chapter with the "negative adaptation" mentioned in the chapter on learning.

8. In what ways are overtones useful and important?

9. A certain low tone has the vibration rate of 25 per second. What is the vibration rate of a tone 6 octaves higher?

10. Explain what is meant by saying that the ear (with its nerve and brain connections) is quite a good analyzer of sounds.

CHAPTER XVI. Thinking

1. How does reasoning differ from simpler sorts of thinking?

2. What are some of the difficulties in reasoning?

3. Point out the resemblances and differences between animal trial and error at one extreme and scientific investigation at the other.

4. Give an example to show what is meant by "seeing the implications."

5. How can the validity of a logical conclusion be tested?

6. Can any conclusion be drawn from these two premises?

Some *X* is *Y*;
No *X* is *Z*.

Try to think this out verbally and then by use of diagrams. How did you reach a conclusion, and how sure of it are you?

7. What emotions and desires influence a person toward belief or toward doubt of a proposition?

8. Give an animistic conception of the fact that a river flows toward the sea, and also a mechanistic conception.

9. By aid of the Index, assemble the various cases in which "set" has been found to be an important factor.

10. Show that some intelligence test items call for relational thinking (pp. 103-111).

CHAPTER XVII. Imagination

1. Show that make-believe can be used as an aid in serious thinking or inventing—"Let this stand for so-and-so."

2. Why do night dreams, more than day dreams, seem real at the time?

3. How does "recency value" interfere with recalling a name, reaching a decision, solving a problem?

4. Can the writer who said he had "never worked but always played" have been telling the literal truth?

5. Show that both imagination and criticism depend on the use of past experience.

6. What personality traits are tied up with imagination?

7. Why is it important to have a good try at solving a problem before laying it aside to "incubate"?

8. Show that conscious purpose would be impossible without imagination.

9. When you are offended at a person you are apt to indulge in autistic thinking about him. Illustrate this statement.

10. Show that invention, while it uses material from past experience, has also to do something like what was called "abstraction" in the preceding chapter.

CHAPTER XVIII. Personal Applications

1. What is the "psychological point of view" and how far can it be carried over into everyday life?

2. Discuss the difficulties of adjustment to adult life.

3. "Face the facts" is said to be an important rule for avoiding maladjustments. How would it help?

4. What contribution does the subject or patient make toward his cure when treated by hypnotic suggestion and when treated by psychoanalysis?

5. How are "transfer" and "transference" alike and different?

6. If you wish to be a psychological counselor or to help some friend who is somewhat maladjusted, what guidance can you obtain from the methods of the psychotherapists?

7. Discuss the question whether teamwork is a better social ideal than altruism.

8. Assemble from the previous chapters the points that appeal to you as having most value in the management of personal life.

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